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ABSTRACT

This is the teacher's guide for the required, interdisciplinary, ninth-year environmental science course for the New York City Schools. One hundred twenty lesson plans, divided into nine units, are presented. Areas of study include the living and non-living environment, ecosystems, population, urban ecology, energy and technology, pollution, and environmental analysis. Individual lessons are conceptualized and process oriented. Each lesson contains enrichment material for investigating areas of interest. Student laboratory worksheets and data sheets are included. The appendices contain suggested field trip sites, student projects, selected student and teacher references, resource organizations, career information, and sources of audio-visual materials. (BT)

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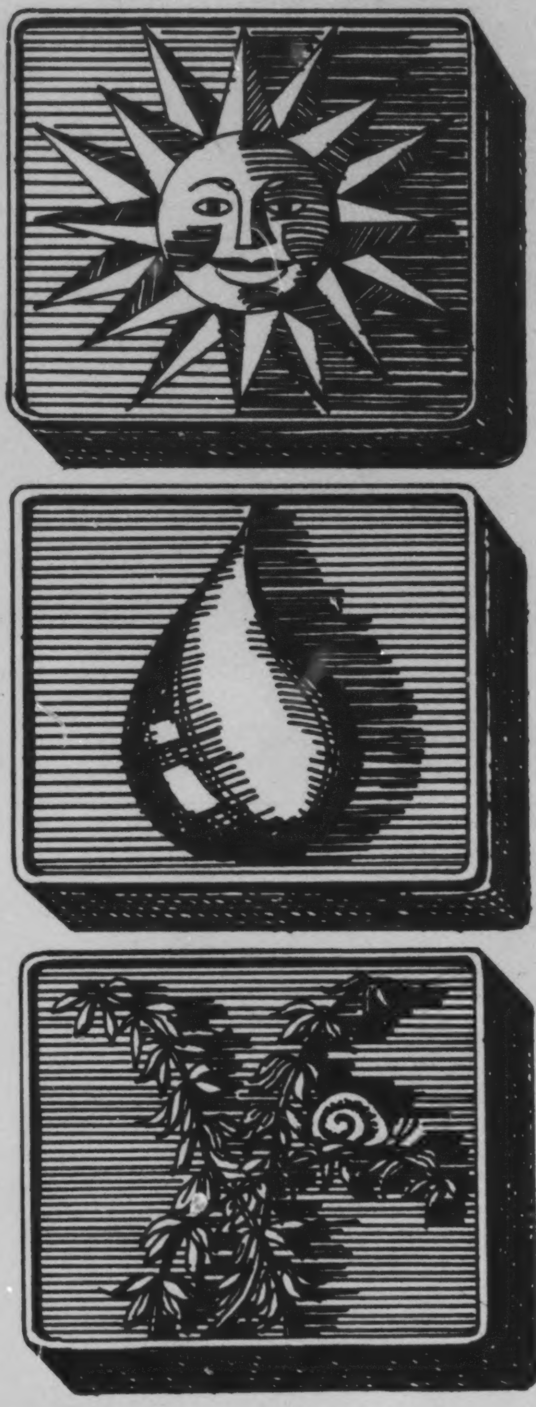
ENVIRONMENTAL SCIENCE

GRADE 9



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Charlotte Frank, director (acting), Center for Curriculum Development, and Sam Fried, assistant director of science, Center for Mathematics and Science, provided overall supervision.

The first draft was developed by teachers,
   Alan Ascher,
   Michael Haas, and
   Denise DiRienzo-Skalecky (formerly assigned) at South Shore High School, Brooklyn, N.Y.

Leonard Bernstein, science teacher at the Arthur Schomburg Intermediate School 201, edited and prepared the document for distribution.

Joseph Feld designed the cover.

ENVIRONMENTAL SCIENCE

Grade 9

Introduction

Environmental education is not new but has been presented under different names for the past 100 years. Whether we are considering nature study, outdoor education, camping or ecology, the message is still the same: to develop an understanding and concern for the earth and its finite resources.

One of the major issues of the 1970's is the environment. People have begun to understand the highly complex nature of the ecosystem. For many, new insights have led to growing concerns. World-wide population size has climbed over the 4 billion mark. This has increased the need for natural resources. A chain of events has followed. The rampant use of natural resources has released toxic substances into our air, land, and water, thus destroying many natural habitats of these areas. In addition, natural balances have been upset, with potentially dangerous consequences. These events have left their mark not only on the earth but on humans and on the entire balance of nature.

It is our role as educators to develop in students an awareness, a concern, and an ability to observe and evaluate the effects of human action on the environment. As a nation we must not overlook the global need for caring for the earth and its resources and to provide the best quality environment for the greatest number of people.

The trend in modern science has been to study smaller and smaller components of different systems. It is necessary to take a step back to see the whole picture and how these components fit together. One of the greatest sensations for the first astronaut who landed on the moon was to see the whole earth in its magnificence. Through environmental science our students will begin to gain a greater understanding and appreciation of the biosphere of which they are such an intimate part.

Objectives

To develop in pupils the ability to conceptualize using both physical and mathematical models

To develop an understanding of the need for keeping records in the form of observations, graphs, and numerical data

To increase the power of pupil observation for field and laboratory activities

To increase the appreciation, concern, and care for living things found in nature

To develop within students an understanding of our natural resources

To increase the student's environmental awareness, knowledge, and sensitivity

To develop attitudes and understandings concerning the interrelationships within the ecosystem and the fragile nature of the living environment

To involve the student in meaningful projects concerning environmental issues in their community

To make students aware of the career and vocational opportunities in the environmental field

To make students aware of the need to protect their local environment using the appropriate laws established for this purpose

The Philosophy of the Program

Environmental Science is designed as a ninth year science course, rather than as an elective, because environmental studies are vital to all of our students. Environmental issues are constantly in the news. If our students are to be responsible adults, they must be able to deal with these issues. Attitudinal changes will lead to the development of an environmental ethic for future generations.

The program enables students to develop a framework for gaining insights and understandings of our present environmental situation. Students will have an opportunity to discover many things about the world around them. This will enable them to apply properly scientific knowledge to an appreciation of the phenomena in the natural and human-made environment.

The content and development of this program are interdisciplinary. Therefore, students are exposed to many of the sciences which helps them better understand the complex nature of the world in which they live. Too often students have the impression that science has nothing to do with their world. Discussions of the social implications of environmental issues will allow for better understanding of the far reaching effects that humans have on the environment.

The city represents the ultimate application of science and technology to everyday life. Much of the curriculum deals with the impact of technology on the students and the community. Environmental Science is a science with a conscience; it allows the students to investigate their environment and the problems they find there. The 1960's were a decade of tremendous technological advancement while the 1970's appear to be the decade of social evaluation of the world that science has created.

How To Use This Book

This book contains a basic core of 120 lesson plans which are divided into nine units. Individual lessons are conceptualized and process oriented. Also, each lesson contains significant enrichment material through which opportunities are provided for the students to investigate areas of interest at their own level.

More material is provided than can actually be covered in a one year program. For this reason, teachers are urged to be selective in terms of topic development and time allocation. A section for additional teacher notes is provided and teachers are encouraged to suppliment each lesson with notes and questions that are appropriate to the class level and interest.

Student laboratory worksheets and data sheets are structured for student use and these should be duplicated for distribution. To insure success in the laboratory, teacher demonstrations and student exercises should be performed in advance by the teacher.

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UNIT I

INTRODUCTION TO THE ENVIRONMENT

An important aspect of any science program is a sound foundation in the proper methods of inquiry. Unit I addresses itself to this need. The unit affords the student an opportunity to make observations, collect relevant data, and use investigational skills in evaluating and solving problems. Throughout this program, students are encouraged to use and develop these skills.

The initial lessons are designed to help students recognize and interpret the significance of topical environmental issues. In attempting to deal with these issues, students will become acquainted with the skills and personnel required to resolve potential environmental problems.

Lesson 1 The Senses and the Power of Observation

Aim: Do you see what I see?

Materials

meterstick	100 ml graduated cylinder
3 - 250 ml beakers	lemon flavored soda
phenolphthalein	brown paper bag
6 m HCl	baby food jar
0.1 m NaOH	teaspoon
medicine dropper	food coloring

Preparation of Materials

Each of the following materials should be prepared prior to class.

a) Prepare 3 labelled 250 ml beakers as follows:
Beaker A: 3 drops phenolphthalein
Beaker B: 3 drops 0.1 m NaCl
Beaker C: 3 drops 6 m HCl

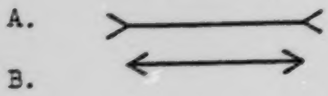
b) Mysterious Bag Solution: Fill a clean baby food jar with a lemon flavored soda. (Any colorless soda may be used). Add several drops of food coloring. Cover the jar and place it into the brown paper bag.

Objectives

To collect data by making observations
To record information
To make inferences based on observational data
To recognize the difference between observations and inference

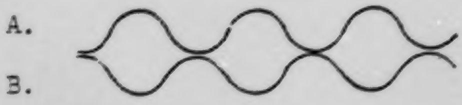
Strategies

1. a) Draw the following on the board.



Elicit student reactions regarding the length of each arrow. List the responses on the board. Have a student measure the length of each arrow and report the results to the class.

b) Draw the following on the board.



Elicit the number of times the two lines appear to touch. Call upon students seated in the front, middle, and rear of the room. Encourage students to explain their answers.

Develop a class discussion centering on the concept that things are not always what they appear to be.

2. Should you believe everything you see?

   a) Add 100 ml of water to Beaker A. Ask several students to describe the contents of Beaker A.

   b) Pour the contents of Beaker A into Beaker B. (Color change should occur). Ask several students to describe what happened.

   c) Pour the contents of Beaker B into Beaker C. (Color should disappear). Ask the students to describe what happened.

   Challenge students to explain how they were able to describe the color changes that took place in the experiment. Elicit that careful observation was necessary to describe the changes that took place.

   Challenge students to explain why each of the color changes took place. Elicit that the contents of one beaker caused a color change to occur in each of the other beakers. Suggest that this conclusion is based upon observation and collected data. Define inference as a statement or conclusion based upon observation and data. The more accurate the data, the more accurate the inference.

3. To reinforce and summarize the learnings of this lesson, perform the following exercise using the Mysterious Bag Solution.

   Designate 6 student participants as follows:

   -The Recorder

   -The Pickpocket

   -The Eavesdropper

   -The Bloodhound

   -The Peeping Tom

   -The Wine Taster

The Recorder remains in the room while the other participants are sent out of the room and asked to enter one at a time.

Each participant does what is indicated below and describes his or her observations, which the Recorder notes on the board.

Pickpocket- Places hand in bag.

Eavesdropper- Closes eyes and listens carefully while teacher shakes bag.

Bloodhound- Smells contents of jar when teacher removes lid.

Peeping Tom- Views contents of bag.

Wine Taster- Uses a teaspoon to taste a drop of the liquid taken from the jar. Student should be cautioned NOT to swallow the liquid.

a) Have the recorder note their observations on the board.

b) Review all of the data.

c) Encourage students to make an inference as to what the Mysterious Bag Solution is.

4. If students have not already done so, identify the contents of the Mysterious Bag Solution.

   Stress the fact that observations must be carefully made, and that data must be accurate to be of value. Lead students to the understanding that inferences may sometimes be errors in judgement.

5. Elicit the differences between an observation and an inference.

Enrichment

a) To a friend: Without naming the object, describe an object found in your home as completely as possible. Can your friend identify the object?

b) Describe a room at home. Use all of your senses.
Can your friend identify the room?

Lesson 2 Scientific Method - Lab Activity

Aim: How can the scientific method be used in problem solving?

Materials

MacIntosh apples
petri dish
aluminum foil
250 ml beakers
plastic knives
cellophane wrap
plastic bags
paper towels

Preparation of Materials

At least one hour prior to class, cut an apple into several slices. Place these slices into one half of a petri dish. Do not cover.

Objectives

To be able to identify and state a problem
To develop an hypothesis
To design a controlled experiment to test the hypothesis
To be able to draw conclusions
To understand the use of the scientific method

Strategies

1. Develop a class discussion concerning student experiences with slices of apple that have been left exposed to the air. Elicit the effects of exposure of fruits to the air.

2. Offer a student a piece of fresh-sliced apple and one of the exposed slices. Encourage the student to select either slice and state his or her reason for preference.

3. Based upon the above, challenge students to suggest a problem that might arise for a person in the apple-slicing business.

4. Congratulate students on becoming members of the Professional Apple Slicers Association. Advise them that the problem is theirs to solve. Suggest that they may want to follow certain steps in solving the problem. Introduce these steps as a part of the scientific method.

5. Develop the concept that many scientists employ a number of steps in approaching a solution to a problem.

6. Summarize the steps in the Scientific Method:

   a) State the problem clearly.
   b) What can you find out about the problem? (Collecting relevant data).
   c) Make an educated guess or hypothesis about how you would solve the problem.

- d) Design an experiment to test your hypothesis. Use a variable and a control.
- e) Observe your experiment carefully.
- f) Record your observations (data) carefully.
- g) Draw a conclusion (inference) based upon your observations.
- h) Report your results.

7. Before students begin the laboratory exercise, review the meaning of variable and control as these terms apply to the scientific method. Establish that these terms serve as a means of comparison.

8. Distribute student laboratory worksheets. Circulate among the students as they work through the problem. Give encouragement and assistance as required.

Additional Teacher Notes

STUDENT LABORATORY WORKSHEET

Lesson 2 How can the scientific method be used in problem solving?

Name______________________________ Date_______________ Section___________

Introduction

You have been given a problem to solve. In helping to find a solution, you will be using the scientific method. Work through each step in the order suggested. Your teacher will supply any materials you may need. Remember! Careful observations will allow you to make accurate inferences!

As you work on this activity, fill in the information required at each step.

1. What is the problem you are trying to solve?

   Problem: ____

   ____

2. Make an educated guess, or an hypothesis that you can test to help you to solve the problem.

   Hypothesis: ____

   ____

3. What materials will you need to test your hypothesis?

   Materials: ____

   ____

4. What steps would you take to prove your hypothesis?

   Experimental Procedure: ______________________________________

   ____

5. How can you show that what you did, and only what you did was the solution to the problem? The scientist refers to this part of an experiment as a control.

   What is the control in your experiment?

   Control: ____

   ____

6. Make a chart showing what you did and what you observed.

Data: ______________________________

____

Method	Observations

7. What conclusions can you draw based on your observations?

Conclusions:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Problem Summary

1. What is the scientific method? ______________________________

   ____

2. Why is the scientific method an important tool of the scientist? ______________________________

   ____

3. How is the scientific method used in problem solving?

   ____

   ____

Lesson 3 Environmental Problems

Aim: What's the problem?

Materials

copies of a newspaper article dealing with an environmental problem

Objectives

To develop the concept of environment
To assist the student in recognizing an environmental problem
To interpret newspaper headlines and articles
To recognize the impact of environmental problems
To apply the Scientific Method to the solution of environmental problems

Strategies

1. Challenge students to define the term environment. Establish that scientists refer to the surroundings of living things as their environment. Develop the understanding that the environment consists of both living and non-living factors.

2. Distribute copies of the newspaper article. Encourage students to read the article. You may want to have one student read aloud while the rest of the class reads along silently.

3. To assist students in identifying and interpreting the problem, raise the following questions for class discussion.

   a) What problem is discussed in the article?
   b) What caused the problem?
   c) How does the problem affect the environment?
   d) How might the problem become more serious if action is not taken?
   e) Who is responsible for solving the problem?
   f) What solutions, if any, are suggested in the article?

4. Have students suggest how they might go about solving the problem. Encourage student reactions to these suggestions.

5. From their readings and/or experiences, have students suggest other environmental problems. List these on the board and encourage the class to offer possible solutions to these problems.

Enrichment

Read an article in a newspaper or magazine dealing with an environmental problem. Include the title, author, source, and date of publication.

a) What is the problem?
b) What effects might this problem have on the environment?
c) What are some possible solutions to the problem?
d) How practical are your suggestions? How do you know?

Lesson 4 Environmental Quality

Aim: How is the environment studied?

Objectives

To evaluate the impact of an environmental problem
To understand the role of scientists in solving environmental problems
To become aware of the career opportunities available in the environmental sciences

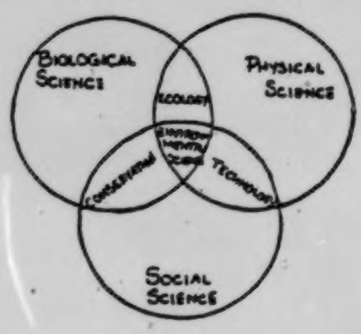
Strategies

1. Review the environmental problem article distributed in Lesson 3. Challenge students to suggest some further problems or conditions that might result from the situation reported. List these on the board.

2. Encourage students to determine the kind of knowledge or expertise that might be required in finding solutions to the suggested problems or conditions.

3. Use the worksheet entitled "Who Does What?" to illustrate the possible role of scientists and/or other specialists in solving a particular aspect of the problem. Also, elicit problems that might require the expertise of more than one type of specialist.

4. Develop the following diagram of interrelationships using the list of scientific careers.



5. Offer information to students, in the form of publications, to illustrate the requirements for each of the environmental careers.

Enrichment

Choose a career from the list, and describe 5 problems that you would help solve.

STUDENT LABORATORY WORKSHEET

Lesson 4 How is the environment studied?

Name ______________________ Date __________ Section ________

Who Does What?

Scientists	Jobs	Role in Solving Problem
Biological Scientist	Studies living things	
Microbiologist	Microscopic life	
Marine Biologist	Sea life	
Zoologist	Animals	
Botanist	Plants	
Entomologist	Insects	
Physical Scientist	Studies the nature of matter	
Chemist	Reactions of matter	
Oceanographer	Features of the ocean	
Geologist	Structure of the earth	
Physicist	Matter and energy	
Meterologist	Weather	
Social Scientist	Studies the relationships between people and their world	
Economist	Money and spending	
Political Scientist	Government and laws	
Sociologist	Society and people	
Psychologist	Human behavior	
Technologist	Studies the application of science to human needs	
Engineer	Designs and constructs various things for human use	
Ecologist	Studies the relationships between living things and their environment	
Conservationist	Wise use of resources	
Environmental Scientist	People's relationship with their environment	

Lesson 5 The Local Environment

Aim: How is a survey used to study the environment?

Materials

floor plan of school
pictures of local community
school building survey form
map of local community
New York City map
community survey form

Objectives

To understand how a survey is used to study the environment
To observe the structure of the local urban ecosystem
To recognize the factors present in the urban environment
To locate problems in the local environment
To analyze problems in the local environment

Strategies

1. Use a floor plan of the school to familiarize students with "school geography." Review the plan with the class. If codes and symbols are used, help students understand their meaning.

2. Distribute and explain the use of the school building survey form. Guide the students to an understanding that the survey form is a tool to be used to record data in an organized manner. Stress the fact that this form will enable students to learn about the school as an environment.

3. Take the students on a tour of the school building. Ask them to carefully observe the many factors that make up this environment. Have them complete the school building survey form.

4. Encourage students to evaluate their experiences. Suggest that they limit their remarks to the data contained on the survey form. Elicit the advantages of using a survey form to study the environment.

5. Establish the fact that the school building is one of many environments in which students live and operate. Elicit that another such environment is the local community. Ask students how they might best study this environment. Elicit the use of a survey form.

6. Distribute a map of the local community as well as a detailed New York City map. Guide the students to an understanding of the location of their community in relation to the city as a whole.

7. Distribute and explain the use of the community survey form. Tell the students that careful observations are important in helping them learn about this environment.

8. Through class discussion, again encourage students to evaluate their experiences. Ask students to explain how and why a survey is used to study the environment.

Enrichment

Construct a model survey form to be used to gather data for one of the hospitals in your community.

ADDITIONAL TEACHER NOTES

STUDENT SURVEY FORM-THE SCHOOL BUILDING

Lesson 5 How is a survey used to study the environment?

Name________________________________ Date__________ Section___________

Introduction

Your first investigation into environmental conditions will be your own school building. Each school building has its own complex systems that provide for the many activities that occur inside a learning center. Use as many of your senses to learn as much as possible about your school environment.

Observations

1. Structure and Appearance
   - a) Describe the general outside shape of the building. ____________________
   - b) How many sides does the building have? ____________
   - c) What is the most common building material used inside the building?____________
   - d) How many levels (floors) are in the building? ____________
   - e) How old is the school building? ____________
   - f) What do you like about the appearance ____________ ____________________
   - g) What do you dislike about the appearance? ____________ ____________________

2. Population
   - a) What is the present student register of the school? ____________________
   - b) For how many students was the building designed?____________
   - c) What is the average number of classrooms on each floor? ____________
   - d) What is the maximum number of students this school can hold if the average class size is 34? ____________
   - e) Estimate the number of students in the students' cafeteria ______ gym______ total classrooms ______
   - f) How do the number of students in different classrooms compare? ____________
   - g) What other organisms live in the school building besides humans? ____________

3. Energy
   - a) What is the source of energy for heating and lighting the building? ____________
   - b) Where can you find temperature readings? ____________ ____________________
   - c) Are all the rooms the same temperature? ____________
   - d) What special features do the windows have for controlling the amount of heat entering or leaving the room? ____________ ____________________
   - e) What evidence is there of energy being wasted? ____________ ____________________

f. What evidence is there of energy being conserved? ______________
____

4. Pollution and Pollution Control

a) Air Pollution:
What evidence of air pollution is there from the school building of its immediate surroundings? ______________
____
When does this usually occur? ______________

b) Noise Pollution:
Rate the level of noise in each area. Circle your choice.

CLASSROOMS	quiet	moderate	loud
CAFETERIA	quiet	moderate	loud
HALLWAYS (during class)	quiet	moderate	loud
HALLWAYS (during change)	quiet	moderate	loud
GYMNASIUM	quiet	moderate	loud

What special materials have been used in the building to control the noise level? ______________

c) Solid Waste Pollution·
Name the sources that contribute to solid waste material in the school. ______________
____
How are solid wastes removed from the school premises?
____
____
How often are the classrooms cleaned? ______________
____
Which area(s) of the school shows the greatest evidence of solid waste pollution? ______________
____

d) Water Pollution:
How many lavatories are there in the school? ______________
Girls ______ Boys ______
How many drinking fountains are there in the school?
____

STUDENT SURVEY FORM - THE COMMUNITY

Lesson 5 How is a survey used to study the environment?

Name ______________________ Date ____________ Section ______

Introduction

Your block, like your school is part of your environment. Just as you surveyed your school, you will survey the block on which you live. Walk slowly up and down both sides of the street. Carefully observe what is happening.

Observations

1. Aesthetics: How does your block look? ______________
   a) How many trees are planted on your block? ______________
   b) What is the condition of these trees? ______________
   c) How are these trees different as compared to trees in the park? ______________
   d) What large buildings, apartment houses, schools, factories, hospitals, etc. are located on your block? ______________
   e) Where are telephone wires or other power lines on your block located? ______________
   f) What place is there nearby where you can go to relax? ______________

2. Air pollution
   a) What clues on your block would you look for? ______________
   b) What are the greatest sources of air pollution on your block? ______________
   c) What evidence is there of air pollution now? ______________
   d) What factors might increase or decrease air pollution levels on your block? ______________
   e) How would you rate today's air pollution level on your block? Circle one.

      Satisfactory Unsatisfactory

3. Noise pollution
   a) Rate today's noise pollution level on you block. Circle one.

      Quiet Moderate Loud Deafening

b) What are the greatest sources of noise pollution on your block? ____________________

c) Suggest some ways your block could be made quieter.

4. Solid Wastes
   a) How many garbage disposal containers of any kind are there on your block? ____________________
   b) What evidence is there of littering on your block?
   c) What types of litter do you see on your block? ____________
   d) Where are signs posted warning against littering?

5. Energy
   a) Give as many examples as possible to show how energy is being used on your block. ____________________
   b) Where does there seem to be an "energy shortage" on your block? ____________________
   c) Which company supplies New York City with electrical energy? gas energy? coal energy? ____________________

UNIT II

THE NON-LIVING ENVIRONMENT

As an introduction to the study of the ecosystem, Unit II is concerned with the physical or abiotic factors of the environment.

Beginning with a chemical analysis of the Pyramid of Life, the basic chemistry of the atom is developed and discussed. After developing an understanding of basic atomic structure, the chemical nature of the physical environment is developed. Emphasis is placed on the cyclic nature of natural resources through an explanation of biogeochemical cycles. Students are given the opportunity to investigate the abiotic components of an ecosystem by using a variety of measurements. They are lead to the understanding that energy is the driving force within the ecosystem.

Lesson 6 The Pyramid of Life

Aim: How are living things and their environment organized?

Materials

charts or models of various plants and animals
molecular models of hydrogen and oxygen

Objectives

To understand the organization of matter and the environment
To be able to analyze a total structure in terms of the parts that make it up
To recognize the relationship of the total environment to the parts which compose it

Strategies

1. Develop a class discussion centering on the fact that living things are complex but organized systems. Guide students to an understanding that although this organization may not always be evident, it can be observed and studied.

2. Expand the concept of organization to include such things as rocks, minerals, metals, etc. Elicit that matter is structured and that it consists of atoms and molecules.

3. Use the molecular models to illustrate the combination of atoms to form a molecule of water.

   a) Elicit the definition of an atom. Define an atom as the smallest unit of matter.
   e.g., H_2, O_2, N_2, C

   b) Elicit the definition of a molecule. Define a molecule as a complex unit formed by the combination of atoms.
   e.g., H_2O, CO_2, $C_6H_{12}O_6$

4. Elicit that atoms and molecules are the smallest integral units of non-living things. Challenge students to identify the smallest unit of a living thing. Elicit that the cell is the smallest unit of any living thing. Define a cell as the smallest unit of life.

5. Display charts or models of various plants and animals. Raise the question, "If a piece of leaf or skin were examined under the microscope, what might you observe?" Elicit that groups of cells would be observed. Explain that groups of similar cells often work together to perform a particular function. Define a tissue as a group of cells which are similar in structure and function.

6. What tissues would you find in the leg of a frog?
   Elicit: muscle, bone, skin, blood, and nerve.

7. What tissues would you find in a plant stem?
Elicit: epidermis (covering tissue), xylem and phloem (conducting tissue), and cambium (specialized growth tissue).

8. How are tissues organized?

Elicit that tissues are organized to form organs.
Define organs as groups of different tissues that perform a similar function.

Examples of animal organs are: heart, lungs, kidneys, liver and sense organs.
Examples of plant organs are: roots, stem, leaf, and flower.

9. How are organs organized?

   a) Elicit that organs are organized into organ systems. Define an organ system as a group of related organs that perform a similar function.

   b) Define an organism as a living thing.

10. In what type of environment are frogs found?
Elicit that frogs are found in pond and lake environments.

11. Define population as all of the organisms of the same kind living in a particular place.

12. What other organisms might live in a pond?

Elicit the names of various pond organisms.
Develop the concept that a pond contains many different populations which make up a community.

13. Besides living things, what else might be found in a pond?

Elicit that water, rocks, mud, sand, gravel, and gases may be found in a pond.

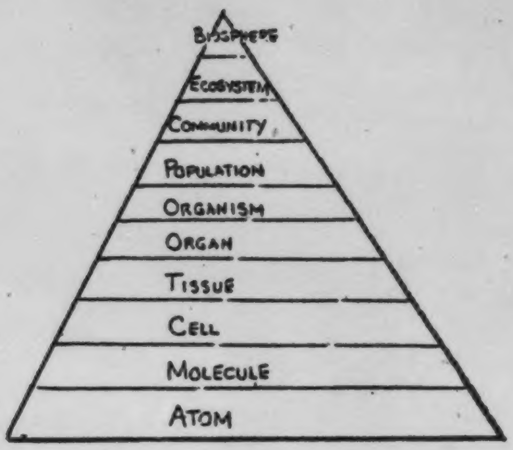
14. Develop the concept of an ecosystem.
Define an ecosystem as an ecological community composed of both living and non-living things.

15. Ask students where else we can find living things on earth.

Elicit that living things may be found in forests, oceans, lakes, and cities.
Define biosphere as all the portions of the earth that support life.

16. Construct a pyramid to illustrate the organization of the structure of matter and the environment.

PYRAMID OF LIFE


BIOSPHERE
ECOSYSTEM
COMMUNITY
POPULATION
ORGANISM
ORGAN
TISSUE
CELL
MOLECULE
ATOM

Enrichment

A biome is a community of living things in a major ecological region.

a) Describe a tropical biome.

b) Describe a polar biome.

ADDITIONAL TEACHER NOTES

Lesson 7 Properties of Matter - Lab Activity

Aim: How can we measure the properties of an object?

Materials

metric rulers (15cm length) balances, blocks of wood, metal, styrofoam

Objectives

To measure an object using metric measurement
To calculate the volume of an object
To weigh an object
To calculate the density of an object

Strategies

1. Demonstrate the proper use of the balance for students.
2. Number individual blocks of wood, metal, and styrofoam.
3. Divide students into small groups and distribute one of each object to be measured to each group.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 7 How can we measure the properities of an object?

Name ______________________ Date __________ Section __________

Introduction

All of the objects around you are made of matter. By using your senses (sight, hearing, taste, touch, and smell), you can identify nearly all of these objects. Matter occurs in three states: solid, liquid, and gas. All types of matter. regardless of their state, have two properties in common: volume and mass.

Volume is the amount of space an object occupies. Solid objects have a definite shape and a definite volume. Liquids have a definite volume but no definite shape. They take the shape of whatever container they are put into. Gases have neither a definite shape nor volume. A gas can be kept together only in a closed container. A gas will spread out to fill any container it is put into.

Mass is the measure of the amount of matter an object has. It is very difficult to measure the mass of an object directly. Instead, we measure the weight of an object. Weight is the measurement of the pull of the earth's gravity on an object.

In order to compare two different objects and determine which one has more mass (more matter) we must compare equal amounts of the two objects. To say that water weighs more than paper has little meaning, because we are not saying how much water (a drop? a glassful? an ocean?) or how much paper (a postage stamp? a sheet of looseleaf? the New York Sunday Times?) We can make a comparison only if we are using equal volumes. This comparison is known as density, or the amount of mass in a certain volume.

In this laboratory exercise you will be determining the properities of mass and volume. Your teacher will supply you with several objects. You will measure them, calculate their volume, estimate their mass by weighing them, and finally compare their masses after you have calculated the density of each object.

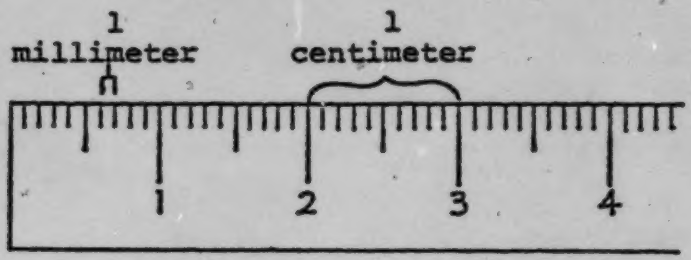
Materials

metric ruler
blocks of wood
styrofoam
balance
metal

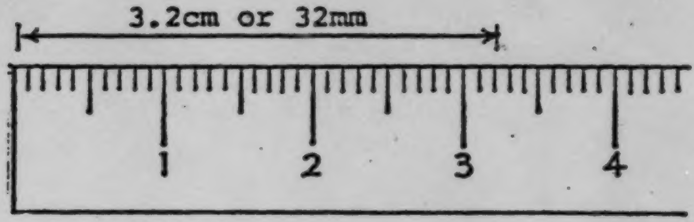
Procedure

1. Examine the metric ruler. Compare it to the following diagram. The labelled units are only a small part of a longer unit of measure known as the meter. A meter is about the size of 1 yard. A meter stick is too long for measuring small objects, such as the blocks.

The meter is subdivided into 100 smaller units known as centimeters (cm). These are more useful units for your purposes. The centimeters are numbered on your ruler. Even the centimeters can be divided into smaller units. Each centimeter contains 10 smaller units called millimeters (mm).



2. Length can easily be measured using a metric ruler. Suppose a line measures a little more than 3 cm. Look at the illustration.

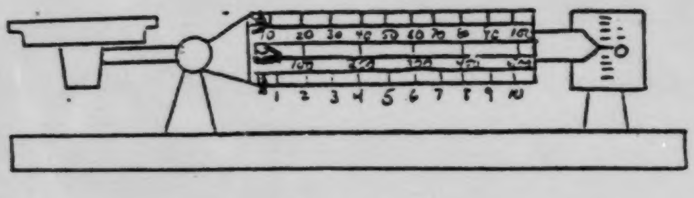


The line measures 3cm and 2mm. This can be written as 3.2cm or 32mm.

3. Measure the length, width, and depth of each object your teacher has given you. Record each measurement on Table 1.

4. To calculate the volume of the object, you must multiply these three measurements: length x width x depth. Since you are multiplying cm x cm x cm, your answer will be in cubic centimeters (cm^3). Calculate the volume of each object and record it in Table 1.

5. Using the balance, weigh each object. The unit of mass in the metric system is the gram (g). Enter the mass of each object in Table 1.



6. To find the density of each object, use the formula:

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

The density is found by dividing the mass by the volume.

Calculate the density of each object. Enter your results in Table 1.

Table 1 Properties of Matter

	Wood No. ____	Metal No. ____	Styrofoam No. ____
Length (cm)			
Width (cm)			
Depth (cm)			
Volume (cm^3)			
Mass (g)			
Density (g/cm^3)			

Post Lab Questions

1. List the three materials you studied in the order of decreasing density (most dense first).
2. What are two distinguishing properties of matter?
3. Give two examples of substances that are ordinarily found in a) solid form b) liquid form c) gas form
4. How would you calculate the density of a glass of water?

Lesson 8 Atomic Structure and the Periodic Table

Aim: What are atoms made of?

Materials

Chart or overhead transparency of Periodic Table, student hand-outs of Periodic Table, samples of C, S, Fe, Al, Pb, Hg, a magnet, a balance

Objectives

To obtain information on atomic structure from the Periodic Table
To understand that every atom has the same basic structure
To understand that atoms of different elements differ from one another in the number of protons, neutrons, and electrons they contain

Strategies

1. Display sample elements. Elicit the different properities of each of the elements, e.g., color, physical state, magnetic properties, weight differences between samples of the same size (density).

2. Identify each of the samples as elements.
   Define an element as a substance made up of just one kind of atom.

3. Explain that all of the samples are made up of atoms.
   This being the case, challenge students to account for the differences in the observed properties.

   a) Elicit that the atoms of different elements must differ.

   b) Define an atom as the smallest particle of an element that still retains the properties of that element.

   c) Develop the concept that atoms are made up of sub-particles: protons, neutrons, and electrons.

4. Distribute copies of the Periodic Table.

   a) Have students determine the number of different elements.

   b) State that there are 92 natural elements.

   c) Elicit that these 92 natural elements are found in rocks, air, water, and living things.

5. Develop a list of the names of some of the most common elements and their symbols, e.g., H_2, C, N_2, C_2, Si, Na, Al, S, Ca, Fe. Hg, He, Pb

6. Illustrate how the Periodic Table can be used to determine the differences between atoms.

   Since all atoms are made of protons, neutrons, and electrons, their difference must be due to different amounts of each.

7. Demonstrate the structure of the carbon atom.

   Introduce the following terms:

   Atomic Number: the number of protons (or electrons)
   Atomic Weight: the number of protons and number of neutrons, or weight of nucleus, the center of the atom.

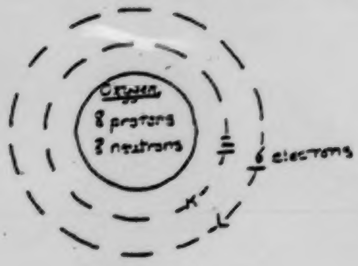
8. Draw a comparison between the structure of an atom and the structure of the solar system. The nucleus is at the center of the atom (the sun is at the center of the solar system). In a manner similar to the planets' orbit around the sun, the electrons orbit around the nucleus. (Use an atomic model to aid in visualizing this concept).

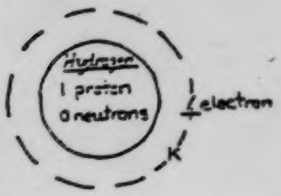
9. Develop the understanding that electrons travel around the nucleus in a path or orbit. Define this path as a shell. Each shell can hold a maximum number of electrons.

   1st shell-K shell-2 electrons
   2nd shell-L shell-8 electrons
   3rd shell-M shell-8 electrons

10. The number of protons equals the number of electrons. Elicit the number of electrons in a carbon atom. Elicit the arrangement of these electrons into shells.

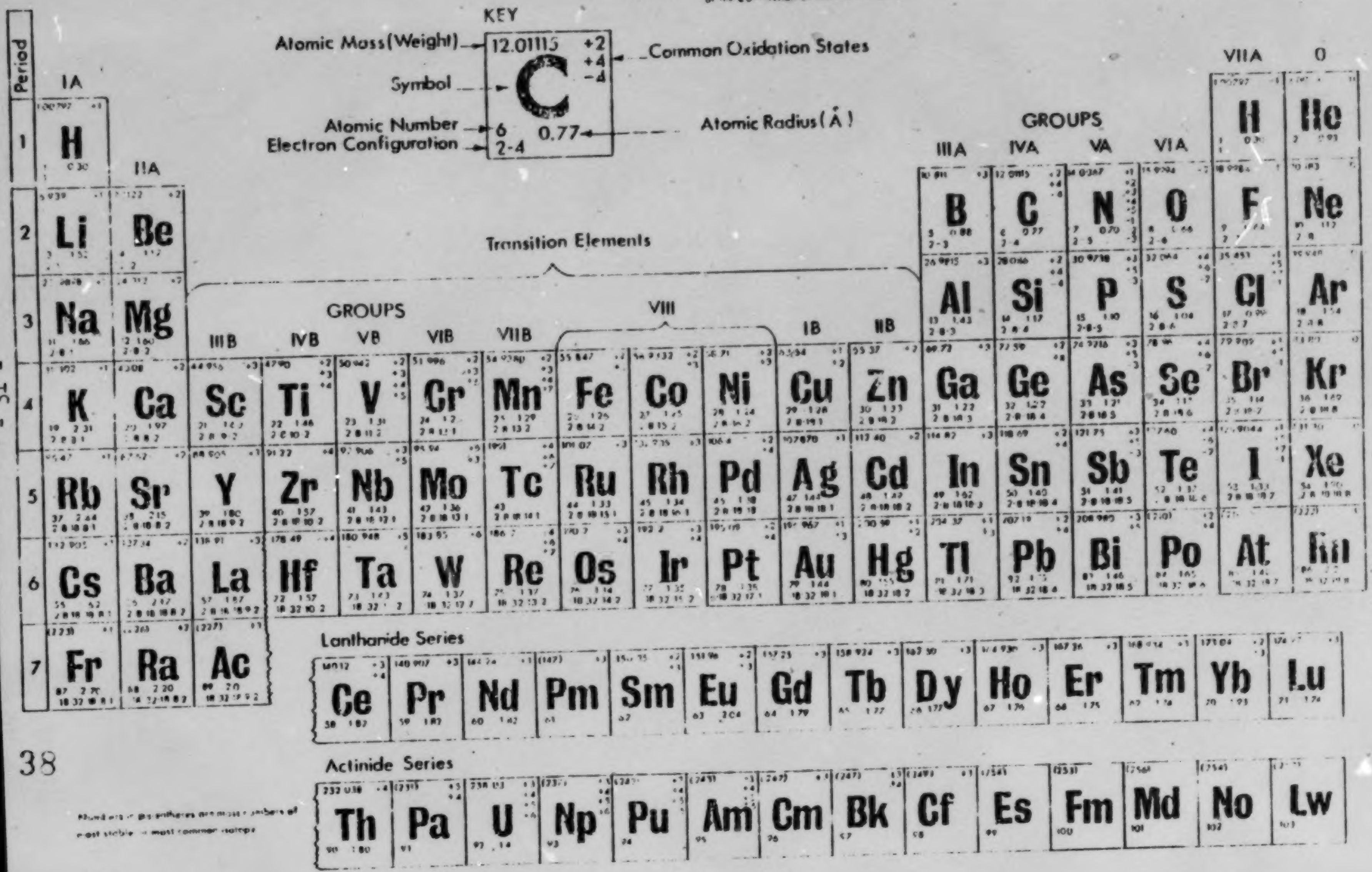
11. Elicit the structure of the oxygen and hydrogen atoms.





Periodic Table of the Elements

Atomic weights conform to the 1961 values of the Commission on Atomic Weights



KEY

Atomic Mass(Weight) — 12.01115

Symbol — C

Atomic Number — 6

Electron Configuration — 2-4

Common Oxidation States — +2 +4 −4

Atomic Radius(Å) — 0.77

Transition Elements

Period	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1	H																H	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac															

Lanthanide Series

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

Actinide Series

Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw

Numbers in parentheses are mass numbers of most stable or most common isotope

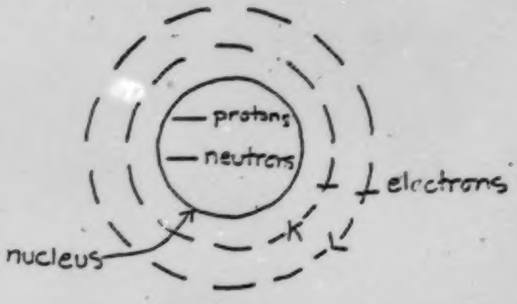
STUDENT LABORATORY WORKSHEET

Lesson 8 What are atoms made of?

Name ______________________ Date __________ Section __________

Using your Periodic Table of the Elements, draw a picture of the following atoms. Fill in the name and symbol of the element, and indicate the number of protons and neutrons, plus the arrangement of electrons.

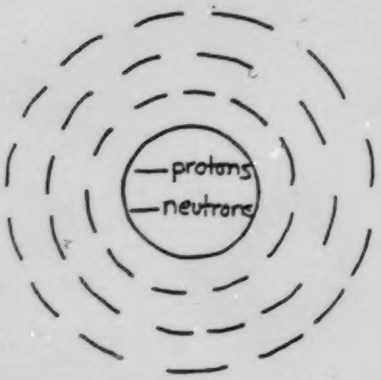
(1) Nitrogen The symbol is _____.


protons
neutrons
electrons
K
L
nucleus

At No = _____ = number of _____

At Wt = _____ = number of _____ + _____

(2) Mg is the symbol for __________


protons
neutrons

At No = _____

At Wt = _____

(3) The symbol for aluminum is _____

At No = _____

At Wt = _____

(4) O is the symbol for ______________

Try to draw the entire picture by yourself.

At No = _____

At Wt = _____

(5) The symbol for sodium is _____

Lesson 9 Atomic Structure and Valence

Aim: How can we draw an atom?

Materials

worksheets on atomic structure, chart or overhead transparency of Periodic Table.

Objectives

To draw a Bohr model of the atom by using the Periodic Table of the Elements
To learn the charge present on a proton, neutron, or electron
To be able to determine the valence of an atom from its electronic structure

Strategies

1. Distribute worksheets and elicit from students the structure of the Na atom. Review previous terms.

2. Permit students to work independently on remaining atomic structures. Check students' work as they progress, to provide assistance where necessary.

3. After students complete worksheets, have them place their results on the chalkboard.

4. Elicit from students the number of electrons needed to complete the outermost shell of each atom. This is the valence number.

5. Develop the following:

number of electrons in outer shell	what atom does to complete outermost shell	valence
1	lose 1	+1
2	lose 2	+2
3	lose 3	+3
4	lose or gain 4	+4 or -4
5	gain 3	-3
6	gain 2	-2
7	gain 1	-1
8	shell complete	0

Enrichment

Draw a picture of the following atoms: helium, hydrogen, sulfur.

Determine the valence of each.

Lesson 10 Atomic Bonding

Aim: How do atoms join together to form new substances?

Materials

Hoffman apparatus	2 test tubes
2 wooden splints	safety matches

Objectives

To observe the different properties of a compound as compared to its elements

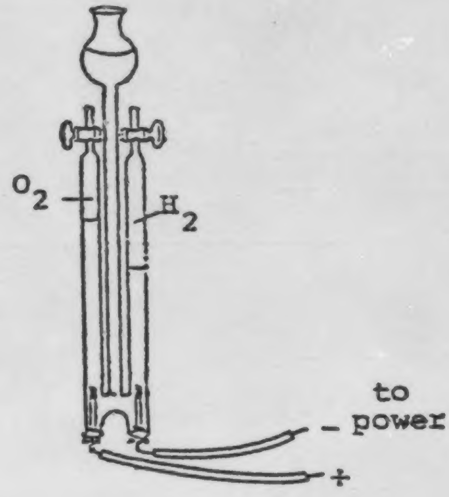
To recognize the difference between sharing and transfer of electrons

To determine the number of atoms in a molecule by inspection of its empirical formula

Strategies

1. Demonstrate the Hoffman apparatus for students. Allow them to identify where the oxygen, hydrogen, and water are located in the apparatus. Challenge students to explain their observations. Ask how the volumes of hydrogen and oxygen compare.

2. Some substances are made of more than one element. These substances are known as compounds. Define a compound as a substance formed by the chemical union of two or more elements. Water is a compound formed from H_2 and O_2.



Hoffman Apparatus

3. List the properties of H_2, O_2, and H_2O that can be observed by students: color, odor, state, and transparency.

   Demonstrate combustibility characteristics by collecting samples from apparatus and testing with a glowing splint.

4. Elicit that compounds have entirely different properties from either of the elements of which they are composed.

5. Review the structure of the H_2 and O_2 atoms with the class. Draw these atoms on the board. Allow students to determine the valence of each. Elicit the formula for water from students. Explain its meaning: 2 atoms of H_2 and 1 atom of O_2. Remind students of the volumes of each gas in the Hoffman apparatus.

6. Allow students to explain why this ratio (2:1) of H_2 to O_2 is needed for a complete water molecule (a group of two or more atoms joined together).

7. Illustrate how the electrons are shared between the H_2 and O_2 atoms. This type of sharing between atoms is known as a covalent bond. In covalent bonding, atoms are joined because they share electrons.

8. Review the structure of the Na and Cl_2 atoms with students. Briefly mention the properties of each:

   Na: solid, metal, very reactive
   Cl_2: gas, yellow-green color, poisonous

   Encourage students to determine the valence of each.

9. Challenge students to determine how these atoms may combine. Develop the concept that a bond formed by the transfer of electrons from one atom to another is called an ionic bond.

10. The new compound formed is NaCl (1 atom of each). Its name is sodium chloride or table salt. Permit students to compare the properties of NaCl with Na and Cl_2.

    Have a student taste a clean sample of table salt. Demonstrate the proper method for doing this.

Enrichment

If Hoffman apparatus is not available, use:
a) Preparation of H_2 from reaction of Zn with HCl
b) Preparation of O_2 from reaction of hydrogen peroxide with $KMnO_4$

Lesson 11 Molecular Formulas

Aim: How can we determine the number of atoms in a molecule?

Objectives

To calculate the number of atoms in a molecule from inspection of its molecular formula
To determine valence from information on the Periodic Table of the Elements
To write the formula for a compound using the cross-valence method

Strategies

1. List the following molecular formulas on the board:

H_2SO_4	H_2O
NaCl	$C_{12}H_{22}O_{11}$

Ask students to determine the names of the elements that each molecule is made of and the number of atoms of each element in the molecule.

2. Stress that there is only one correct molecular formula for each substance. The easiest method to write a correct molecular formula is by finding its valence. (Review)

3. List the following on the board:

H_2, O_2, C, Cl_2, Na, Ca, Al, Br_2, S, N_2

Encourage students to find the valence of each.

4. Illustrate the cross-valence method.

$H_2^{+1} \times O_1^{-2}$ the formula for water is H_2O

$Na_1^{+1} \times Cl_1^{-1}$ the formula for salt is NaCl

5. Examples for students to work on independently while teacher provides individual assistance:

HCl, Al_2O_3, KCl, $MgBr_2$, $CaCl_2$, CCl_4, NH_3

6. Reduction of subscripts to lowest terms:

$C_2^{+4}O_4^{-2}$ - C_2O_4 is reduced to CO_2

7. Examples for students to work on independently while teacher provides individual assistance:

   CaO, MgO, CaS, MgS

Enrichment

Write the correct molecular formulas for the following combination of atoms:

HF, MgCl, AlCl, AlBr, CaBr

ADDITIONAL TEACHER NOTES

Lesson 12 Chemical Reactions- Lab Activity

Aim: What happens during a chemical reaction?

Materials

steel wool
test tube
copper sulfate solution

Preparation of Materials

Copper sulfate solution: Dissolve 10 grams of copper sulfate in 500 ml of water.

Prepare enough pea-sized steel wool balls for the entire class.

Objectives

To show how one atom can replace another in a chemical reaction
To predict the outcome of a chemical reaction

Strategies

1. This lesson is designed to demonstrate chemical reactions through the use of a simple, single replacement reaction.

2. Review formula writing and cross-valence method of determining chemical formulas.

$$Fe^{+2} + O^{-2} \longrightarrow FeO$$

$$Fe^{+3} + O^{-2} \longrightarrow Fe_2O_3$$

$$Zn + 2HCl \longrightarrow H_2 + ZnCl_2$$

$$Zn + H_2SO_4 \longrightarrow H_2 + ZnSO_4$$

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 12 What happens during a chemical reaction?

Name ______________________________ Date _____________ Section ______________

Introduction

During a chemical reaction, one atom may replace another atom in a molecule. If only one type of atom is replaced, we say the reaction is a single replacement reaction. If two different atoms are replaced, we say the reaction is a double replacement reaction. In this experiment you will see the results of a single replacement reaction. In many single replacement reactions one of the products may be easily seen while the other product is soluble (can be dissolved in water) and not seen.

Materials

steel wool
test tube
copper sulfate solution

Procedure

1. Place a small ball of steel wool into a test tube.
2. Pour about 5cm of copper sulfate solution into the test tube.
3. After about 5 minutes, remove the steel wool and observe the results.
4. After you are sure of your results, clean up your equipment.

Observations and Conclusions

1. What color did the steel wool turn? ______________________________
   Where did this color come from? ______________________________
   ____
2. What happened to the iron atoms in the steel wool, where did they go? ______________________________
   ____
3. Complete the following equation:

$$Fe + CuSO_4 \longrightarrow \underline{\hspace{3cm}} + \underline{\hspace{2cm}}SO_4$$

4. What type of reaction is this? ______________________________
   ____
   Explain why. ______________________________
   ____
5. Why is iron sulfate not seen in the test tube?
   ____

Lesson 13 Energy Flow in an Ecosystem

Aim: What makes it go?

Materials

battery-powered device
photocell
flat, heavy object
battery
galvanometer or light meter

Objectives

To construct a definition of energy
To understand the types of energy available in the environment
To understand the transformation of energy in the environment
To understand the relationships between matter and energy.

Strategies

1. Place the battery-powered device on the dek. Challenge a student to operate the device. What did the battery supply to the device? Elicit that the battery supplied energy.

2. Construct the following definition of energy: Energy is the ability to do work.

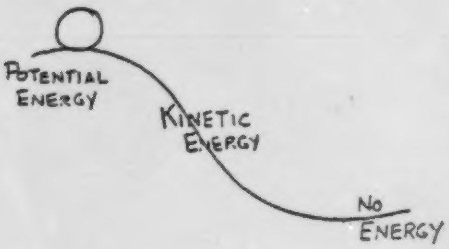
3. Refer to the device again. Ask students to observe it. Develop the concept that the energy stored in the battery causes motion. Elicit a definition of work. Define work as moving an object through a distance.

4. Pick up a flat, heavy object. Ask students if there is energy in the object. Drop the object. (Try to startle the class with the noise).

5. Repeat the above, this time hold the object close to the surface you are dropping it on. Elicit a difference in sound level; why do these differences exist?

6. Drop an object on the floor. Ask what has happened to the potential energy.

7. Place the following on the board: (Ball on hill).



8. Where does the kinetic energy come from? Elicit that potential energy changes into kinetic energy. Kinetic energy is energy of motion.

9. Place a photocell in the light; use sunlight or artificial light. Elicit that light is a form of energy.

10. The sun is the primary source of energy for the earth.

11. Place the following on the chalkboard:

Composition of the sun:	light hydrogen atoms	(97%)
	heavy helium atoms	(3%)
	heavy elements	(trace)

Hydrogen does not combine with helium.

12. Elicit the types of reactions that might take place on the sun.

a) helium → hydrogen- Problem: too little helium
b) hydrogen → helium- Good: large supply of hydrogen available

13. One atom of hydrogen weighs 1.008
One atom of helium weighs 4.003

Ask for a volunteer to calculate the following:

4 hydrogen atoms weigh $1.008 \times 4 = 4.032$
1 helium atom weighs 4.003
Difference in weight = 0.029

14. What happens to the matter that is left over?

The matter is converted into energy. This was explained by Einstein in his equation $E=mc^2$

15. Summary - Laws of Energy

1. Energy cannot be created or destroyed.
2. Energy can be changed from one form to another. This is shown in the equation $E=mc^2$.

Enrichment

List five uses for energy in your home.

Lesson 14 Abiotic Factors: Carbon-Oxygen Cycle

Aim: How are carbon and oxygen used in the environment?

Materials

two sealed jars, each containing water plant and snail, lamp, package of cupcakes

Preparation of Materials

Prior to classroom use, place one of the sealed jars under a light source for at least 48 hours. The other jar should be kept in darkness for the same period of time. Label each jar.

Objectives

To understand the use of solar energy in the environment
To understand the need and importance of photosynthesis
To introduce the concept of interaction between plant and animal life
To appreciate the cyclic nature of carbon and oxygen in the environment

Strategies

1. Display the jars containing the organisms. Elicit the affect of light and darkness on the organisms in each jar.

2. Ask: What relationships exist between the organisms in each of the jars?

   Elicit that plants produce oxygen which is needed by animals. Also, animals produce carbon dioxide which is needed by plants.

3. Define photosynthesis as food manufacture in plants using sunlight.

   Develop the following:

   $$CO_2 + H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + O_2$$

   Elicit that during photosynthesis, carbon dioxide is used as a raw material by plants. During this process, sugar (food) and oxygen are produced. These materials are needed by animals. Guide students to the cyclic nature of carbon dioxide and oxygen.

4. Discuss the energy transfer:

   Sunlight $\xrightarrow{\text{helps to form}}$ Food molecules in plants

5. Elicit the names of some quick energy foods.
   Have a student eat a cupcake. Ask the student to trace the source of energy obtained from the cupcake.

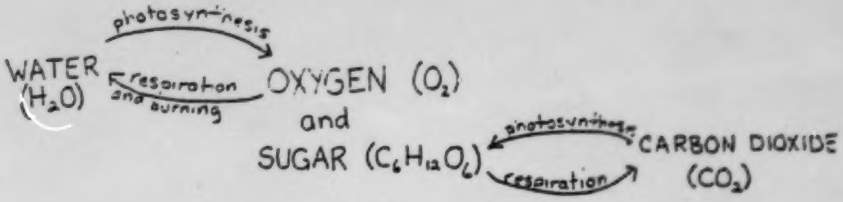
   cupcake → flour → wheat → plant → sunlight

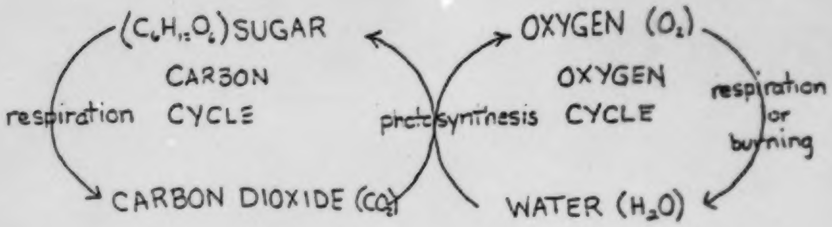
6. Define respiration as using oxygen to obtain energy stored in foods.

   Developing the following:

   $$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O + \underline{\text{Energy}}$$

7. Challenge students to explain why we do not run out of carbon dioxide and oxygen.
   Emphasize the cyclic nature of carbon dioxide and oxygen through the use of the following chart:


photosynthesis
WATER (H_2O)
respiration and burning
OXYGEN (O_2)
and
SUGAR ($C_6H_{12}O_6$)
photosynthesis
respiration
CARBON DIOXIDE (CO_2)


($C_6H_{12}O_6$) SUGAR
CARBON CYCLE
respiration
CARBON DIOXIDE (CO_2)
photosynthesis
OXYGEN (O_2)
OXYGEN CYCLE
respiration or burning
WATER (H_2O)

8. Construct a simple working example of interaction. Quietly ask one student to lean on the person seated alongside. The person should push the student away. The students affect one another.

$$A \underset{\text{AFFECTS}}{\overset{\text{AFFECTS}}{\rightleftarrows}} B$$

$$\text{plants} \rightleftarrows \text{animals}$$

Enrichment

Trace the source of energy in the following foods:
1) a hamburger
2) a slice of bread

Lesson 15 Abiotic Factors: Water Cycle

Aim: How is water cycled in the environment?

Materials

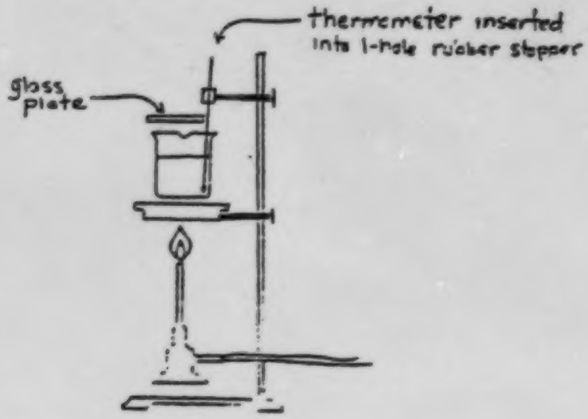
250ml beaker, Fahrenheit-Celsius thermometer, ringstand, clamp, ring, wire gauze, one hole rubber stopper, bunsen burner, flower pot with plant that has been wrapped in a plastic bag for 2-3 days, alcohol, square glass plate, tongs, class set Water Cycle Chart (reproduced)

Objectives

To be able to understand energy transfer
To gain experience in using Fahrenheit and Celsius temperature scales
To understand the nature of the water cycle
To appreciate that the water cycle involves the interaction of living and non-living factors

Strategies

1. Set up the following apparatus:



2. Heat 150ml of water in the beaker. Have a student record the temperature in °F and °C every 30 seconds. Set up the following table on the board:

Start	30		60		90		120		150		180	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C

3. Elicit the fact that heat adds energy to the water in the beaker. Challenge students to define temperature. Elicit that temperature is a measure of heat energy.

4. Challenge the students to explain why the temperature stopped rising when the water started boiling. It may be necessary to review kinetic energy as energy of motion. Define evaporation as the process of molecules leaving the surface of a liquid when they have enough energy.

5. Invite a student to place a drop of alcohol and a drop of water on the back of his or her hand. Which evaporates first? Elicit a general statement about evaporation of liquids based upon this experiment. Establish that different liquids evaporate at different temperatures.

6. Refer back to the beaker of boiling water. Have students recall where the bubbles appear to have come from.
   Why do you suppose the bubbles come from the bottom of the beaker? Elicit that the bottom of the beaker is being heated the most; molecules are leaving the liquid rapidly from the bottom in the form of water vapor bubbles.

7. Boiling: The process of so many molecules leaving the surface of a liquid that bubbles form.

8. Refer the students back to the table on the board.
   At what point did the temperature stop rising in the beaker? 100°C or 212°F.

9. Temperature scale: A measure of heat energy.

   Point out that the divisions on a Celsius thermometer are further apart than the divisions on a Fahrenheit thermometer.

10. Place the following on the board:

$$^{\circ}F = (9/5 \times {}^{\circ}C) + 32$$

$$^{\circ}C = ({}^{o}F - 32) \times 5/9$$

Example: a) Water boils at 100°C; determine its boiling boiling point in °F.

$$^{\circ}F = (9/5 \times 100) + 32$$

$$^{\circ}F = 180 + 32 = 212^{\circ}F$$

b) Convert 50°F to °C.

$$^{\circ}C = ({}^{\circ}F - 32) \times 5/9$$

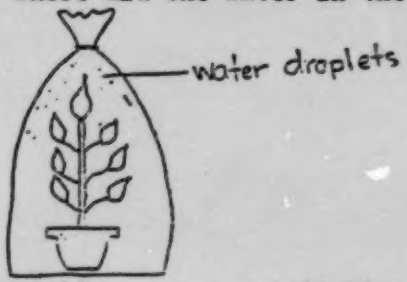
$$^{\circ}C = (50 - 32) \times 5/9$$

$$^{\circ}C = 18 \times 5/9 = 10^{\circ}C$$

11. Using tongs, hold the square glass plate over a beaker of boiling water. Observe what happens.

12. Elicit the change of state associated with the addition or removal of energy.

13. Display a plant in a plastic bag; where did the water in the bag come from?



14. Define transpiration: water loss by evaporation from a plant.

15. Distribute water cycle chart. Elicit from the class the steps in the water cycle.

    Evaporation, transpiration → condensation → precipitation

    Precipitation: A form of water heavy enough to fall from condensed water vapor in clouds.

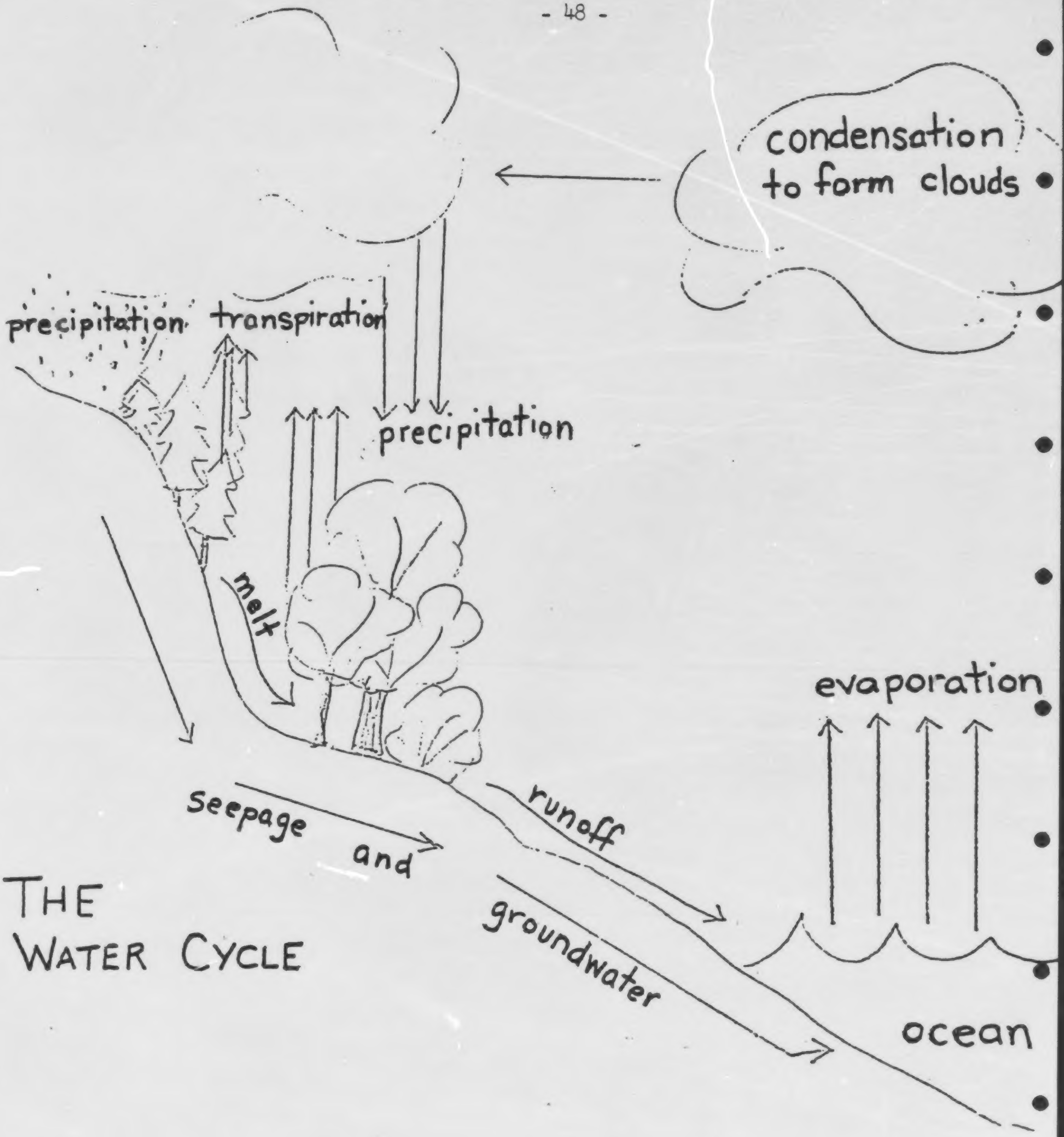
16. Elicit from students forms of precipitation. Responses should include rain, sleet, snow and hail.

17. What happens to precipitation when it hits the ground?
    a) taken up by plants
    b) evaporates
    c) runs off the land into rivers, lakes and oceans
    d) seeps into ground to become part of stored, underground water called groundwater.

Enrichment

A person running a high fever is sponged down with water and alcohol. How does this help lower the person's temperature?

ADDITIONAL TEACHER NOTES


condensation
to form clouds
precipitation
transpiration
precipitation
melt
evaporation
seepage
and
runoff
groundwater
ocean

THE
WATER CYCLE

Lesson 16 Abiotic Factors - Nitrogen Cycle

Aim: How is nitrogen cycled in the environment?

Materials

human hair
egg white
meat
4 test tubes
test tube holder
bunsen burner
tesla coil
nitrogen cycle sheets
dilute nitric acid
copper turnings
clover root (or photo)
safety matches

Objectives

To be able to analyze an organic compound by heating to ash
To understand the cyclic nature of hydrogen
To appreciate the significance of bacteria and decomposition in the environment

Strategies

1. Using separate test tubes for each, heat to ash a small quantity of hair, egg white, and meat. Have students note the sharp, unpleasant odor produced. Point out that this is due to the presence of nitrogen containing protein.

2. Elicit the importance of proteins in the diet - muscle development, growth, etc.

3. Trace the source of protein in muscle tissue.

   Protein in muscle → Protein in meat → Protein in grass

4. Elicit that plants make their own food. Point out that even though nitrogen is 78% of the air, plants and animals cannot use nitrogen gas directly to make protein. Develop that the nitrogen must first be changed into a useable form.

5. If available, turn on the tesla coil for a period of time. Students should note the odor produced. Explain that when electricity is discharged into the air, nitrate (NO_3) is formed.

6. Place the following on the chalkboard:

$$\underset{\text{nitrogen in air}}{N_2} + \underset{\text{oxygen}}{O_2} \xrightarrow[\text{(lightning)}]{\text{electrical discharge}} \underset{\text{nitrate}}{NO_3}$$

7. Hand out nitrogen cycle sheets.

8. Refer to nitrogen cycle sheet. Point out that nitrates can be used by plants to make plant protein.

9. Slowly pour some dilute nitric acid. (HNO_3) into a test tube containing copper turnings. Have students observe the blue-green copper nitrate formed. Challenge students to relate this to what might happen when nitrates formed by lightning combine with material in the soil to form soil nitrates. Define nitrates as molecules that have NO_3 in them, plus another atom. Example: copper nitrate
   Cu NO_3
   copper nitrate

10. The Bible says that, "Man is dust and to dust he will return." Elicit from the class the environmental significance of this quotation.

    Decomposer: An organism which can break down a dead plant or animal to the basic atoms and molecules which make it up. Example - bacteria of decay

11. If available, display the root system of a clover plant. Point out the nodules on the roots.

    Nitrogen fixing bacteria: Bacteria which can take nitrogen from the air and change it into usable nitrates.

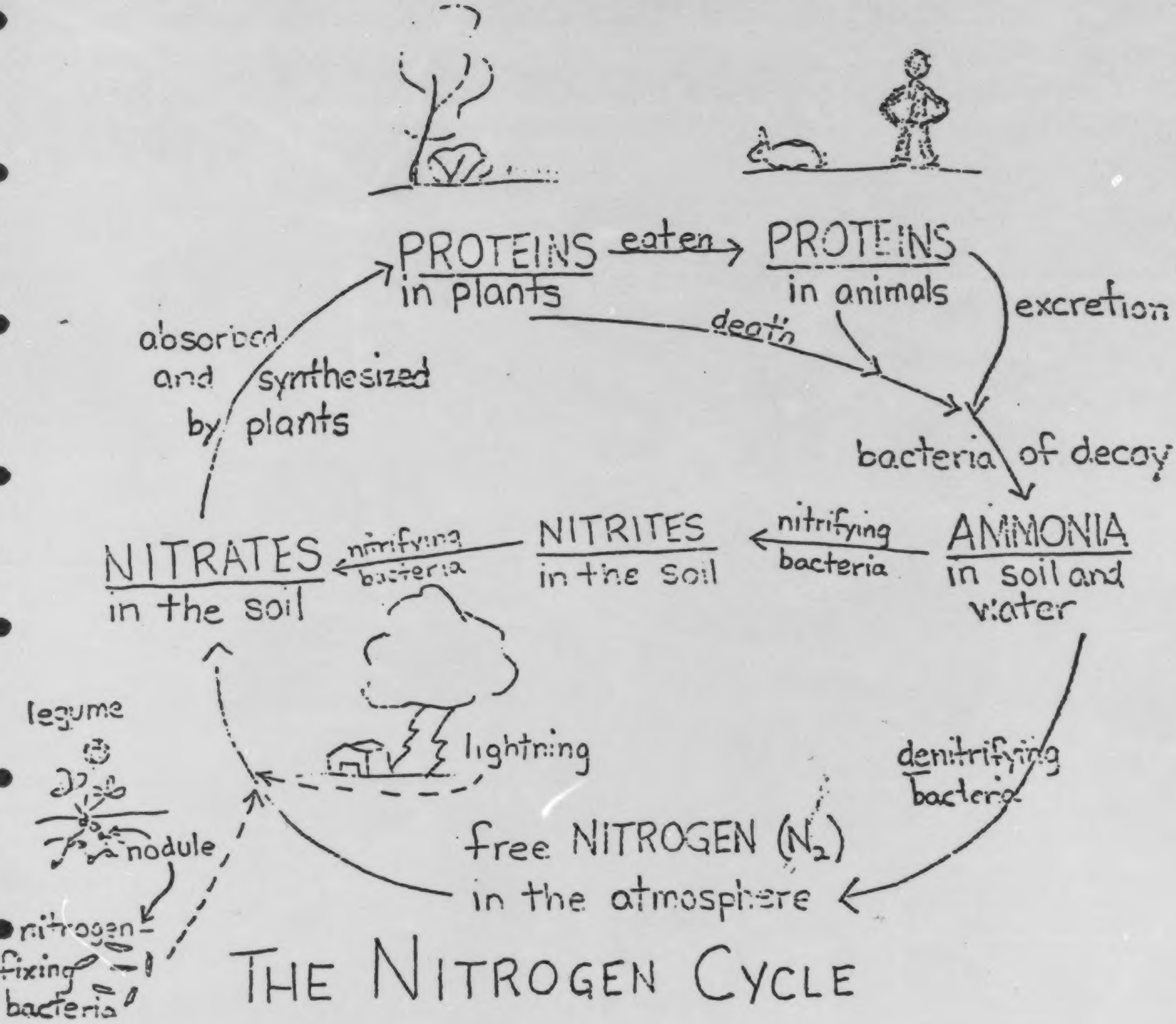
12. What are the advantages to a plant of having nitrogen fixing bacteria on its roots?

    Legume: Plant having nitrogen fixing bacteria living on its roots.

Enrichment

1. Have students look up the meaning of crop rotation.
   a) How can crop rotation help the soil?
   b) A farmer has been growing corn in a field for many years. He is advised to grow legumes, such as clover, in his field for a year. Why is this advice given to him?

ADDITIONAL TEACHER NOTES


PROTEINS
in plants
eaten
PROTEINS
in animals
excretion
death
absorbed
and synthesized
by plants
bacteria of decay
NITRATES
in the soil
nitrifying
bacteria
NITRITES
in the soil
nitrifying
bacteria
AMMONIA
in soil and
water
lightning
denitrifying
bacteria
legume
nodule
nitrogen-
fixing
bacteria
free NITROGEN (N_2)
in the atmosphere

THE NITROGEN CYCLE

Lesson 17 Measurement of Abiotic Factors-Lab Activity

(Field activity or in-class laboratory and demonstration)

Aim: How can abiotic factors in the environment be measured?

Materials

red litmus paper
hydrion paper
sling psychrometer
soil thermometer
watch glass
prepared samples
blue litmus paper
thermometer
wet-dry bulb thermometer
medicine dropper
relative humidity table

Preparation of Materials

Samples for pH testing:
a) mild soap solution
b) lemon juice and water - combine 5 ml lemon juice with 200 ml water
c) 0.1 M HCl
d) sea water (if available)
e) soil suspension - combine 10 g soil with 100 ml water

For indoor soil temperature, place a large flowerpot filled with soil near a sunny window for two hours prior to class time.

If a sling psychrometer is not available, a wet-dry bulb thermometer may be made by placing a bit of damp gauze around the bulb of a thermometer. The gauze may be held in place with a rubber band. Readings on this wet bulb thermometer may be compared to the dry bulb reading. Relative humidity can then be determined from tables available in many Earth Science textbooks or from the National Weather Service.

Objectives

To measure pH using indicator paper
To study the technique of air temperature determination
To understand the measurement of soil temperature
To determine relative humidity by use of the wet-dry bulb thermometer.

Strategies

1. Each of the activities described on the student worksheet can be done as a demonstration or as a student exercise. If time and equipment allow, students should perform as many of the activities as possible.

2. Discuss the importance of abiotic factors. Develop the fact that living things depend upon abiotic factors for survival. Tell the students that in this lesson they will be studying pH, air

temperature, soil temperature, and relative humidity.

3. Divide the class into small groups and distribute the work and data sheets. Circulate among the groups as they perform the required activities.

4. Instruct students on the use of the sling psychrometer and/or wet-dry bulb thermometer. Also, instruct students as to how to use and determine results from the relative humidity table.

ADDITIONAL TEACHER NOTES

TABLE OF RELATIVE HUMIDITY

Dry-Bulb Temperature (°C)	Difference in Temperature (°C)																			
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
10	94	88	82	77	71	66	60	55	50	44	39	34	29	24	20	15	10	6	-	-
11	94	89	83	78	72	67	61	56	51	46	41	36	32	27	22	18	13	9	5	-
12	95	89	84	78	73	68	63	58	53	48	43	39	34	29	25	21	16	12	8	-
13	95	89	84	79	74	69	64	59	54	50	45	41	36	32	28	23	19	15	11	7
14	95	90	85	79	75	70	65	60	56	51	47	42	38	34	30	26	22	18	14	10
15	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	27	24	20	16	13
16	95	90	85	81	76	71	67	63	58	54	50	46	42	38	34	30	26	23	19	15
17	95	90	86	81	76	72	68	64	60	55	51	47	43	40	36	32	28	25	21	18
18	95	91	86	82	77	73	69	65	61	57	53	49	45	41	38	34	30	27	23	20
19	95	91	87	82	78	74	70	65	62	58	54	50	46	43	39	36	32	29	26	22
20	96	91	87	83	78	74	70	66	63	59	55	51	48	44	41	37	34	31	28	24
21	96	91	87	83	79	75	71	67	64	60	56	53	49	46	42	39	36	32	29	26
22	96	92	87	83	80	79	72	68	64	61	57	54	50	47	44	40	37	34	31	28
23	96	92	88	84	80	76	72	69	65	62	58	55	52	48	45	42	39	36	33	30
24	96	92	88	84	80	77	73	69	66	62	59	56	53	49	46	43	40	37	34	31
25	96	92	88	84	81	77	74	70	67	63	60	57	54	50	47	44	41	39	36	33
26	96	92	88	85	81	78	74	71	67	64	61	58	54	51	49	46	43	40	37	34
27	96	92	89	85	82	78	75	71	63	65	62	58	56	54	50	47	44	41	38	36
28	96	93	89	85	82	78	75	72	69	65	62	59	56	53	51	48	45	42	40	37
29	96	93	89	86	82	79	76	72	69	66	63	60	57	54	52	49	46	43	41	38
30	96	93	89	86	83	79	76	73	70	67	64	61	58	55	52	50	47	44	42	39
31	96	93	90	86	83	80	77	73	70	67	64	61	59	56	53	51	48	45	43	40
32	96	93	90	86	83	80	77	74	71	68	65	62	60	57	54	51	49	46	44	41
33	97	93	90	87	83	80	77	74	71	68	66	63	60	57	55	52	50	47	45	42
34	97	93	90	87	84	81	78	75	72	69	66	63	61	58	56	53	51	48	46	43
35	97	94	90	87	84	81	78	75	72	69	67	64	61	59	56	54	51	49	47	44

STUDENT LABORATORY WORKSHEET

Lesson 17 How can abiotic factors in the environment be measured?

Name ______________________________ Date ______________ Section __________

Introduction

You will be involved in a series of activities designed to show how some different abiotic factors are measured. The factors you will measure are pH, air temperature, soil temperature, and relative humidity.

pH is a measure of how acidic or basic a substance is. The scale used to measure pH ranges from 0 to 14. Substances with a pH of 7 are neutral. They are neither acid nor base. Substances with a pH of less than 7 are acids. The lower the number, the stronger the acid. Substances with a pH of more than 7 are bases. The higher the number, the stronger the base. Many acids and bases are important factors in plant and animal growth.

Air and soil temperatures are important factors in determining the kinds of life forms to be found in an area. Plants and animals that live in colder climates have different adaptations from those that live in warmer climates. Organisms that live in the soil are affected by the temperature of the soil. In some places, such as a beach, soil temperatures may be over 50°C. This high temperature prevents many organisms from living there.

The relative humidity or moisture content of the air not only affects human comfort but is also an important factor in determining the types of plants and animals living in an area. Desert organisms live in dry areas while the organisms of a tropical rain forest live in damp or humid areas.

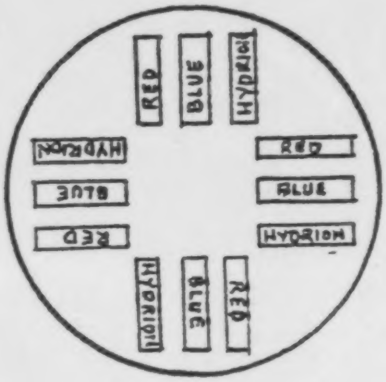
I. pH Measurement

Materials

red litmus paper
hydrion paper
medicine dropper
test samples
blue litmus paper
watch glass
paper towels
student data sheet

Procedure

1. Place small pieces of red litmus paper, blue litmus paper, and hydrion paper around the inside edge of the watch glass as shown.



2. Using the medicine dropper, place one drop of a test sample on one set of test papers. Thoroughly rinse and dry the medicine dropper. Repeat this for each of the other test samples. What color changes took place?

3. Record your observations on the student data sheet.

II. Air Temperature Measurement

Materials

- thermometer
- student data sheet

Procedure

1. Place a thermometer about 6 cm. above the ground. After 5 minutes, record the temperature on the student data sheet.

2. Take two more temperature readings. Use a height of 1 meter and 2 meters above the ground. For each, wait 5 minutes and then record the temperature on the student data sheet.

III. Soil Temperature Measurement

Materials

- soil therometer
- student data sheet

Procedure

1. Place the soil thermometer on the surface of the soil. After 5 minutes record the surface temperature on the student data sheet.

2. Take two more temperature readings; this time beneath the surface of the soil. Use depths of about 5 cm and 10 cm. For each, wait 5 minutes and then record the temperature on the student data sheet.

IV. Relative Humidity Measurement

- sling psychrometer or wet-dry bulb thermometer
- student data sheet
- relative humidity chart

Procedure

1. (FOR SLING PSYCHROMETER) Be certain that no one is standing near you. Wet the gauze wick with water. Swing the apparatus above your head for about 2 minutes. Record the wet and dry bulb readings on the student data sheet. Use these numbers to determine relative humidity from the table.

2. (FOR WET-DRY BULB THERMOMETER) Allow the thermometer to remain undisturbed for 5 minutes. Record the wet and dry bulb readings on the student data sheet. Use these numbers to determine relative humidity from the table.

Questions and Conclusions

1. The pH scale ranges from 0-14. Substances with a pH from 0-6.99 are acids. Substances with a pH of 7 (water) are neutral. Substances with a pH from 7.01-14 are basic. Classify each of the samples you tested as acid, neutral, or basic.
2. What relationship do you suppose exists between plant life and soil pH? How can you find out if you are correct?
3. What relationship is there between temperature and distance above the ground? How do you know?
4. The African continent is hot, yet Mt. Kilimanjaro has a snow-covered peak. How can you explain this?
5. Beach sand is very hot during the day and very cold at night. How can you explain this?
6. What special adaptations do desert organisms have to retard water loss?

STUDENT DATA SHEET

Lesson 17 How can abiotic factors in the environment be measured?

Name ________________________ Date ____________ Section _____

I. pH Measurement

Sample	Color Changes			Acid or Base
	Red Litmus	Blue Litmus	Hydrion Paper	
soap solution				
lemon juice and water				
0.1 M HCl				
sea water				
soil suspension				

II. Air Temperature Measurement

Distance above Surface	Temperature °C
6 cm	
1 M	
2 M	

III. Soil Temperature Measurement

Distance below surface	Temperature °C
At surface	
5 cm	
10 cm	

IV. Relative Humidity Measurement

Bulb	Temperature °C	Relative Humidity
wet		
dry		

UNIT III

THE LIVING ENVIRONMENT

The dynamic nature of an ecosystem is exemplified by the diversity of life. In Unit III, students are exposed to a vast array of living things. They are encouraged to compare and contrast those similarities and differences that are used as a means of classifying living things. An application of these learnings comes about as students use classification techniques to observe and identify organisms during field observations.

Continuity of life in an ecosystem depends upon interactions and interrelationships among plants, animals, and microorganisms. The energy of the ecosystem is captured by the green plant and transferred to other organisms as illustrated by the study of food chains and food webs.

Lesson 18 Classification of Living Things

Aim: Who's who among living things?

Materials

several decks of playing cards
pictures of plants and animals from representative phyla, class set of classification chart.

Objectives

To understand why a system for classification is necessary
To understand some of the characteristics used to classify plants and animals
To observe members of each of the groups of living things

Strategies

1. Divide the class into small groups; give each group a deck of cards. Students must use only the Jacks, Queens and Kings.
    a) Find two differences in the four Queens.
    b) Find at least three differences in the four Kings.
    c) Find two differences in the four Jacks.
2. Challenge students to explain how the entire deck of cards can be sorted. Elicit that differences and similarities exist between each of the suits in the deck and that these differences and similarities can be used as a method of sorting or separating.
3. Introduce the fact that there are millions of plant and animal species on earth. Challenge students to suggest how scientists are able to keep track of such great members and how these are studied. Establish a need for identifying and studying living things. Elicit the need for a system of grouping or classification.
4. Challenge students to describe methods by which organisms may be grouped. Remind them to refer to their experiences with the playing cards. Elicit that organisms may be grouped or classified according to certain similarities.
5. Display pictures of representatives of the various plant and animal phyla. Challenge students to explain why these organisms are grouped as they are.
6. Distribute the classification charts. Again display the pictures and have students identify the organism and its classification.

THE CLASSIFICATION OF LIVING THINGS

THE ANIMAL KINGDOM

CATEGORY PHYLUM	SUB-CATEGORY CLASS	EXAMPLE	MAJOR CHARACTERISTICS
Porous Animals		sponges	Have pores
Hollow Bodied Animals		Jellyfish Portuguese-man-of-war Hydra Sea Anemone Coral	Have tentacles with stinging cells, radial symmetry
Flatworms		tapeworm liverfluke planarian	Can regenerate Are parasitic Bilateral symmetry
Roundworms		trichina hookworm ascaris	Undivided bodies
Segmented Worms		earthworm bloodworm leech sandworm	Segmented worms have body divided into sections or segments
Mollusks		clams, oysters, snails, slugs, scallops, squid, octopus, whelks, limpet, abalone	exoskeleton unsegmented body
Jointed-leg Animals	Crustaceans	lobster, crab, crayfish, shrimp, barnacle	All have an exoskeleton and definite body regions
	Centipedes	centipede millipede	

CATEGORY PHYLUM	SUB-CATEGORY CLASS	EXAMPLE	MAJOR CHARACTERISTICS
	Arachnids	spider, tick, mite, horseshoe, crab, scorpion	8 legs, 2 body parts
	Insects	grasshopper, fly, cockroach, ants, bees, termite, fleas	6 legs, 3 body parts
Spiny-skin Animals		sea-star (starfish) sea urchin. sand dollar, sea cucumber	radial symmetry live only in marine environment
Vertebrates (chordates)	fish	eel, shark, perch, flounder, trout	cold blooded use gills to breathe
	amphibians	frog, toad, salamander	gills in youth lungs in adulthood smooth skin
	reptiles	lizard, snake, turtle, alligator, crocodiles	cold blooded have lungs scaly skin
	birds	chicken,robin, duck,sparrow, hawks, seagulls, ostrich	warm-blooded feather covered skin
	mammals	bat, whale, kangaroo, rodent, rabbit, dog, cat, bear, seal,elephant, horse, sheep, deer, cattle, humans	warm blooded mammary glands hair-covered bodies

THE PROTIST KINGDOM	
Protozoa - One-celled animals	Ameba, Paramecium, Euglena, Stentor
Spore organisms	slime molds
Bacteria	Cocci Spirilla Bacilli
Blue-green algae	
Green algae	diatoms chlorella
Fungi	molds yeast
PLANT KINGDOM	
Without veins (non vascular)	moss, lichen, algae
With veins (vascular)	ferns, conifers - cone bearers, flowering plants - trees, grasses, weeds, wildflowers

Lesson 19 Using Keys and Guides to Identify Living Things

Aim: How can you identify a living thing?

Materials

Assortment of keys and examples of organisms that might be identified with these keys, field guides, diagrams of leaf structure, leaf samples.

Objectives

To identify and explain the use of dichotomous keys
To use a dichotomous key to identify living things
To use other types of keys and guides to identify living things

Strategies

1. Elicit the definition of a key. Develop the concept that a key is a table used for interpreting data. Establish the fact that some keys use only words while others use only pictures. A key that uses only words is a word key. A key that uses only pictures is a picture key.

2. Some keys use an either/or approach for purposes of identification. For example, a leaf may have either jagged edges or smooth edges. The identification choice depends upon one of two characteristics. Keys that approach identification in this manner are generally referred to as Dichotomous Keys.

3. The use of a Dichotomous Word Key can be demonstrated using 5 students.

A Key to a Group of Students

Select 5 students from the class.
3 males -1 with glasses
1 with blond hair
1 with brown hair
2 females -1 short
1 tall

Place the following word key on the chalkboard. The identification or name of each student should be placed in the space marked Name as the identification is made. As each characteristic is sorted, or identified, students are instructed to go on to the next characteristic. The identification continues, in steps, as a process of elimination.

1a. male → go to item 2
1b. female → go to item 4

2a. wears glasses → Name
2b. no glasses → go to item 3

3a. blonde hair → Name
3b. brown hair → Name

4a. short → Name
4b. tall → Name

4. Encourage students to use available keys to identify samples of unidentified organisms.

5. Distribute diagrams of leaf structures and sample leaves.

   a) What type of edge does the leaf have?
   b) What pattern of veins does the leaf have?
   c) How many lobes does this leaf have?
   c) What type of leaf is this?

ADDITIONAL TEACHER NOTES

Lesson 20 Identification of Living Things

Aim: How can a dichotomous key be used to identify leaves and shells?

Materials

Picture key: leaves and shells
dichotomous key: leaves and shells
leaf and shell samples

Objectives

To use a dichotomous key to identify leaf and shell samples
To use a picture key to verify dichotomous key identification

Strategies

1. Distribute dichotomous keys for leaves and shells. Review the use of the key with a sample leaf or shell.
2. Encourage students to identify their samples. Caution them to work carefully and slowly. Allow sufficient time for identification.
3. After students complete the dichotomous key identification, distribute the picture keys for leaves and shells. Encourage students to compare and verify their initial results.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 20

Identification of Living Things

Dichotomous Key-Leaves

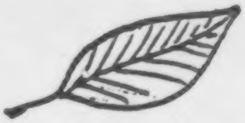
Name________________________ Date__________ Section__________

Directions: Identify only one leaf at a time. Read each pair of statements carefully. Decide which statement best fits the leaf you are identifying. Go to the next pair of statements as directed at the end of the correct statement until you have reached the name of the tree from which the leaf comes.

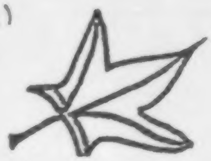
1a. leaf with a jagged edge (lobed or toothed).............go to 2

1b. leaf with a smooth edge ....go to 8

    2a. leaves with pinnate veins ....go to 3
        (like feather)



    2b. leaves with palmate veins ....go to 6
        (like fingers of a hand)



3a. leaf edges lobed (oak) ....go to 4

3b. leaf edge evenly toothed ....go to 5

    4a. lobes are pointed at ends.......................Red Oak

    4b. lobes are rounded at ends ....White Oak

5a. Large rounded teeth..................................Chestnut Oak

5b. sharp pointed teeth..................................American Chestnut

6a. lobes of a leaf have many fine teeth............ go to 7

6b. lobes of a leaf are smooth.......................Norway Maple

7a. three principal lobes ....Red Maple

7b. five principal lobes ....Sugar Maple

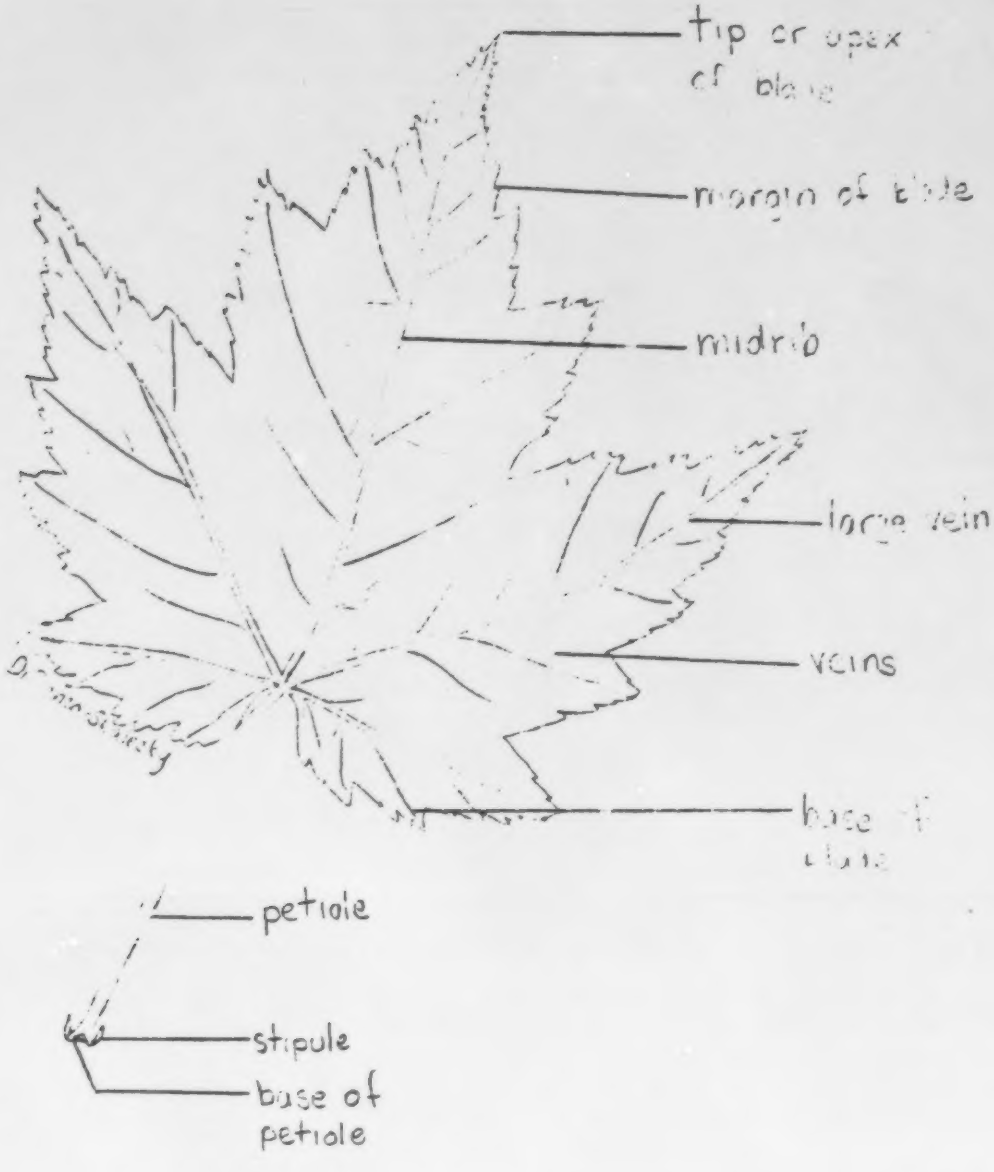
8a. two lobes on either side of midrib..............Tulip tree

8b. no lobes on either side of midrib...............go to 9

9a. broad roundish leaf...............................Dogwood

9b. narrow pointed leaf...............................Ash

Anatomy of a Leaf Blade


tip or apex
of blade
margin of blade
midrib
large vein
veins
base of
blade
petiole
stipule
base of
petiole

About the Tree Table

This Tree Table is published by The Parks Council, Inc. as an aid to increased enjoyment and appreciation of the City's parks. We hope that it provides added pleasure as well as added interest in the parks and their proper care.

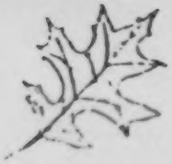
The most common trees to be found in the City's parks are the Norway Maple, Pin Oak, Ginkgo, Sycamore (London Plane) and American Elm. Other important varieties include the Birch, Osage Orange, Hackberry, Tulip, Horsechestnut, Honey Locust, Mulberry, Linden (Basswood) and Ash. More unusual specimens can also be found, but not in such abundance. The greatest range of varieties, of course, is to be found in the City's three Botanical Gardens: Central Park at 105th Street and Fifth Avenue; Brooklyn Botanic Gardens, Flatbush and Washington Avenues; and the New York Botanical Gardens in Bronx Park, 200th Street east of Webster Avenue.

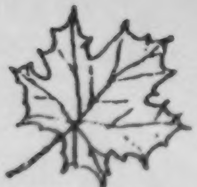
Enjoy Our City's Parks, and Help to Keep Them Clean and Green.

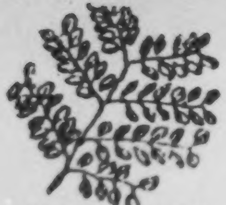
TREE TABLE

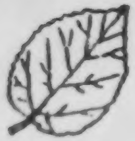
A GUIDE TO THE PRINCIPAL TREES FOUND IN THE CITY'S PARKS

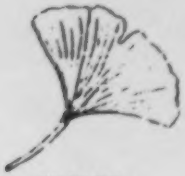
The Parks Council, Inc.
80 Central Park West
New York, New York 10023

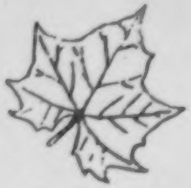

PIN OAK

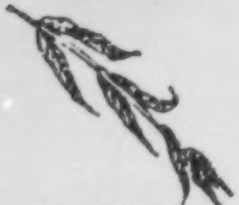

NORWAY MAPLE

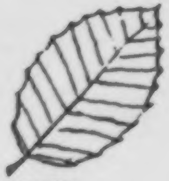

HONEY LOCUST

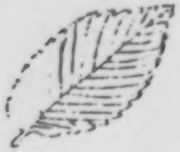

MULBERRY

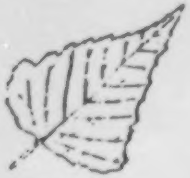

GINKGO

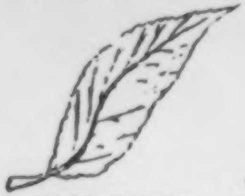

LONDON PLANE

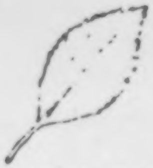

WEEPING WILLOW

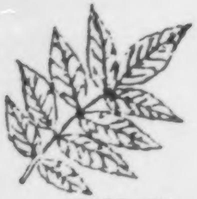

BEECH

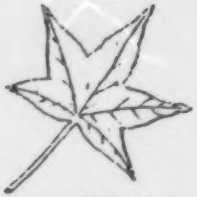

AMERICAN ELM

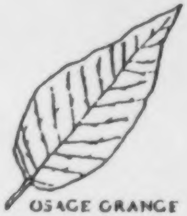

BIRCH

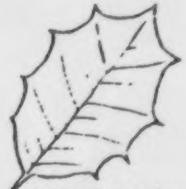

BLACK CHERRY

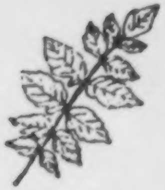

CRABAPPLE

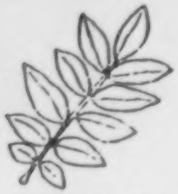

WHITE ASH

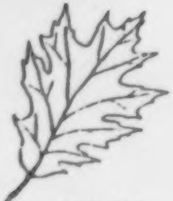

SWEET GUM

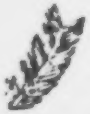

OSAGE ORANGE

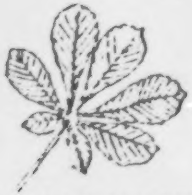

AMERICAN HOLLY

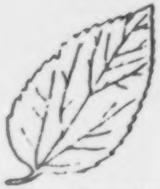

VARNISH TREE

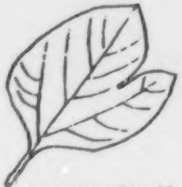

PAGODA TREE

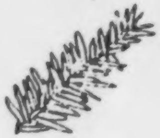

RED OAK

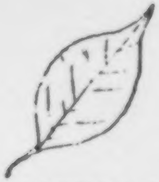

BALD CYPRESS

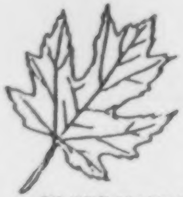

HORSE CHESTNUT

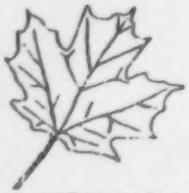

HACKBERRY

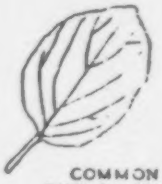

SASSAFRASS

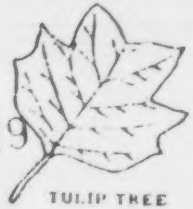

HEMLOCK

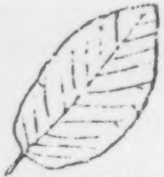

SPINDLE TREE

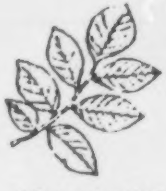

SILVER MAPLE

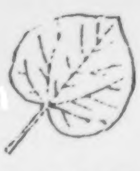

SUGAR MAPLE

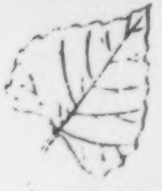

COMMON BUCKTHORN

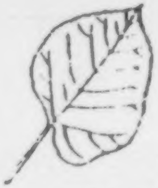

TULIP TREE

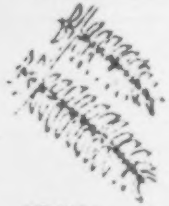

EUR. HORNBEAM

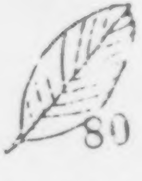

YELLOW WOOD


RED BUD


COTTONWOOD


BASSWOOD


MIMOSA


SWEET BAY

STUDENT LABORATORY WORKSHEET

Lesson 20

Identification of Living Things

Dichotomous Key - Seashells

Name____________________ Date_______________ Section______________

KEY TO THE SEASHELLS

Directions: Identify only one seashell at a time. Read each pair of statements carefully. Decide which statement best matches the seashell you are identifying. Go to the next pair of statements as directed at the end of the correct statement until you have reached the name of the seashell which you are identifying.

1a. shell is spiral shaped.................................Moon snail

1b. shell is not spiral shaped.............................go to 2

    2a. shell is ribbed and fan-like ....Bay Scallop
    (similar to Shell Gasoline trademark)

    2b. shell is not ribbed or fan-like..................go to 3

3a. shell irregularly shaped, heavy. Color is chalky-white, but there may be darker areas that are charcoal-gray.................................Oyster

3b. shell has regular shape ....go to 4

    4a. shell is dark in color (brown or blue), often covered by a peeling skin ....go to 5

    4b. shell is light in color ....go to 6

5a. many ribs coming from narrow end.......................Ribbed mussel

5b. shell without ribs ....Blue mussel

    6a. shell with a platform in back....................Boat shell

    6b. shell without a platform in back.................go to 7

7a. shell with purple markings on inside..................Hardshell clam

7b. shell completely white on inside......................Surf clam

Lesson 21 Using the Quadrat to Measure Species Diversity

Aim: How can we measure the diversity of living things?

Materials - for each team of students

quadrat
plastic container
forceps
Berlese funnel
plastic bags
alcohol
trowel
lamp

Objectives

To develop the idea of species diversity by taking an inventory of an environmental area

To use knowledge of plant and animal characteristics to visually differentiate between different species of plants and animals

To determine the dominant plant and animal in an area

To develop an understanding and appreciation for the variety of living things in the environment

Site

School garden, field, park, beach, or marsh

Strategies

1. In selecting a site to be used for this activity, certain safety factors should be considered. Students should be cautioned to remain with the group and be watchful for glass, rusty nails, and other such objects.

2. Divide the class into several small groups. Each group should be given a set of materials.

3. Advise students that caution should be used when examining plants and animal specimens so as not to injure or damage them. Only one sample of each organism should be collected.

4. The quadrat should be placed on the ground and used as a boundary within which to work.

5. Instruct students to carefully examine each individual plant species. A small, identifiable specimen should be placed in a plastic bag and tagged with an identifying number.

6. Each individual animal species found in the quadrat should be examined. Students may use forceps if necessary but should handle organisms with care. One of each species should be collected and placed in a plastic container adequately filled with alcohol. Number the container.

7. A trowel can be used to dig several centimeters into the soil to

determine if there is any additional life beneath the surface. The sample of soil removed, as well as some of the leaf litter, should be placed in a plastic bag and labelled with the group's number.

8. A Berlese funnel can be set up in the classroom to examine insects, worms and other organisms in the soil. A dissecting microscope can be useful in examining these organisms more carefully.

9. A count should be made of the number of each species found in the quadrat. This information should be placed on a chart set up by the students. Chart should contain:

   a) site
   b) identification number
   c) common name
   d) species name
   e) quantity

10. Each group can display its findings and compare results. A master list can be made on the board of all the species in the area found during the inventory. From this information the dominant plant and animal can be determined.

11. Plant and animal keys or guides can be used to identify each of the species found.

Enrichment

Prepare a soil suspension from the soil collected. Carefully examine the liquid under a microscope. Draw what you see. What kinds of organisms are there? How many did you count? Discuss your findings with the class.

ADDITIONAL TEACHERS NOTES

Lesson 22 Adaptation

Aim: How are living things adapted for their environment?

Materials

masking tape
pictures of animals showing camouflage and mimicry, pictures of bird's beaks

Objectives

To understand that each form of life must adapt to its environment
To appreciate the need for adaptation
To explain how an organism can adapt
To identify adaptation as an evolutionary process

Strategies

1. Using a student volunteer, tape the thumb to the palm of the hand. Ask the student to use the taped hand to pick up coins, keys, or other small objects from the desk. Ask the student to use the taped hand to write on a piece of paper. Call attention to the fact that each of these simple operations becomes extremely difficult without the use of the thumb.

2. Elicit the use of the thumb in everyday life. How might the lack of the thumb limit a person's ability?

3. Develop a class discussion centering on the fact that living things possess certain features that enable them to survive in their particular environment. Elicit that these features are called adaptations. Define an adaptation as a feature of a plant or animal that helps it live in a particular environment.

4. Show students diagrams of bird beaks. Ask why birds have different style beaks? Elicit that birds and other organisms have adaptations of structure and behavior for the purpose of survival, protection and feeding.

5. Have students describe adaptations found in plant leaves; i.e. thin leaves, broad leaves, thorny leaves, spiny leaves, no leaves. Display samples or pictures of some of these forms.

6. Ask how the shape or color of an organism can be an advantage. Explain that camouflage, a passive form of protection allows an organism to blend in with the environment.

7. Discuss the fact that many fish are light-colored on the bottom and dark-colored on top. Why is this an advantage? Elicit that protective coloration is a feature exhibited by many organisms. The coloration affords concealment by allowing the organism to blend in with the environment. In this way, they are somewhat

protected. Give the following examples:

a) pepper moth vs. black moth on trees
b) the fur color of arctic animals
c) the rock and sand color of desert animals
d) brightly colored tropical birds live in brightly colored forests

8. How do animals know to avoid other plants or animals. Elicit the presence of warning markings and/or special coloration; (skunk, black widow spider) which is frequently associated with poisonous. bad-tasting and bad-smelling organisms.

9. Monarch and Viceroy butterflies look alike. Monarch butterflies are bad-tasting to birds. How might the Viceroy butterfly gain advantage from this situation? Define mimicry as a resemblance of an unprotected animal to an unrelated, protected species. Display pictures which illustrate mimicry.

10. Baby birds will sometimes eat food from their mother's mouth. This is an adaptation for feeding. It is a behavior pattern that is natural and unlearned.

Enrichment

1. Describe 5 adaptations that humans have made in order to survive in their environment?

2. Distribute adaptation worksheets. Have students draw the adaptations referred to.

ADAPTATION WORKSHEET

Lesson 22 How are living things adapted for their environment?

Name ________________ Date ________________ Section ________________

ENVIRONMENTAL SCIENCE - SOME PLANT AND ANIMAL ADAPTATIONS

An adaptation is a physical feature of a plant or animal that helps it live in its particular environment. Most adaptations are hereditary; that is, they are passed down from parent to offspring.

The small flat beak of the sparrow is an adaptation that helps it eat seeds and grains. The flat beak is used to crush the seeds that the bird eats.

The hook beak of the hawk is used to tear and rip its prey. The hawk is a hunting bird which swoops down on its prey and tears the flesh with its hooked beak.

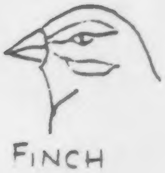
The heron is a fishing bird. It uses its long, slender beak like a spear to catch fish beneath the surface of the water.

The round seed of the burdock plant is covered with spines. These spines will stick to animal fur or people's clothing, allowing the seeds to be carried a great distance.

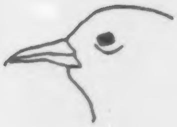
The winged seeds of the maple tree act like gliders. A strong wind can carry the seeds a great distance from the parent tree.

The dandelion produces seeds with parachute-like feather fibers. This special adaptation allows the seeds to be carried for miles on the slightest breeze.

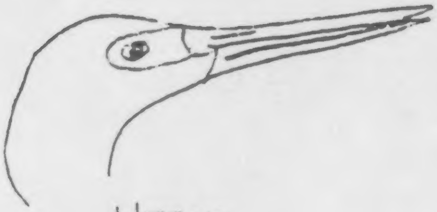
BIRD BEAK ADAPTATIONS



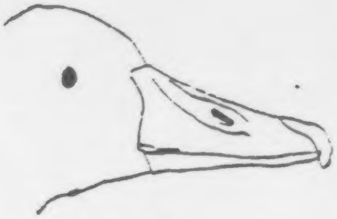
FINCH
SEED - EATER



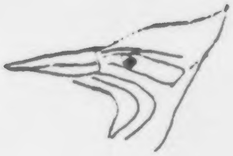
GROUSE
INSECT-EATER



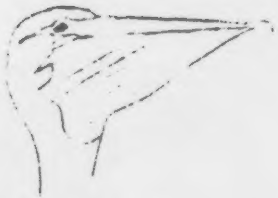
HERON
SPEARING BILL



CANADA GOOSE
STRAINING - BILL



WOODPECKER
CHISEL - BILL



PELICAN
SEINING - BILL

Lesson 23 Energy Transfer

Aim: How does the need for food create a balance in nature?

Materials

60 ml (by volume) dry sucrose
concentrated sulfuric acid
tongs
250 ml beaker
100 ml graduated cylinder
blade of grass or plant leaf

Objectives

To identify producers as basic energy suppliers
To formulate a plan of energy transfer from organism to organism
To define the different levels of consumers in a food chain
To understand the role of decomposers in a food chain

Strategies

1. Review the chemical composition of sugar. Elicit that sugar is made up of carbon, hydrogen, and oxygen molecules. Have students recall that sugar is an energy nutrient. Explain that we can release the energy stored in sugar by adding a small amount of concentrated sulfuric acid (H_2SO_4) to it. The acid will release energy stored in sugar by breaking apart the sugar molecules.

2. Place the dry sucrose into a 250 ml beaker. Carefully add about 10 ml of H_2SO_4 to the sugar. Have the students observe the results. (NOTE: The carbon cylinder produced should be held with the tongs).

3. Invite several students to come up and carefully touch the sides of the beaker. Elicit that a great amount of energy (heat) is generated.

4. Elicit the possible sources of energy given off in this reaction. Define food energy as the energy stored in bonds which hold food molecules together.

5. Display a piece of sugar cane. Have students identify it. Elicit that sugar comes from sugar cane. Challenge students to explain where the plant gets energy to put sugar molecules together (to make sugar).

6. Review the general formula for photosynthesis.

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O} \xrightarrow[\text{sunlight}]{\text{chlorophyll}} \underset{\text{sugar}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{O_2}$$

   Elicit that sunlight is the source of energy.

7. Elicit that one of the major differences between plants and animals is that plants have the ability to manufacture food. Animals do not. Animals depend upon plants for food.

Define a producer as an organism that can manufacture its own food.

8. Display a blade of grass or a plant leaf. Ask the class to name organisms that might eat these plants. Place the names of these organisms on the board. Elicit that the organisms named serve as food for still other organisms. Have students name these organisms.

9. Define a food chain as a process or cycle in nature in which organisms are dependent upon each other for their food. Establish that in a food chain, energy is passed along from one member of the community to another.

10. On the board, establish a food chain similar to the following:

grass → grasshopper → frog → snake

11. Refer to the food chain just established. Elicit the role of each member of the chain.

Place the following operational terms on the board:

Producers- Green plants make their own food.
Consumers- Plants or animals that consume (eat) the producers.

First Level Primary Consumer (1°) - Herbivores - Eat plants
Second Level Secondary Consumer (2°) - Carnivores - Eat herbivores
Third Level Tertiary Consumer (3°) - Carnivores - Eat 2° consumers

12. What type of consumer is a person? Elicit that people eat both plants and animals. Define an omnivore as a consumer that eats both plants and animals.

13. Discuss the role of each in the following food chains:

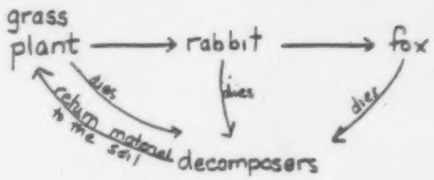
Green plant → Rabbit → Fox
Producer Herbivore Carnivore
1° Consumer 2° Consumer

14. What would happen to this food chain if:
a) the green plants were destroyed
or b) the rabbits died
or c) the foxes were killed

15. Elicit a working definition of the expression "Balance of Nature." Define this as the relationships between plants and animals in their environment which allows the community to survive.

16. Refer to the food chain on the board and to the definition of food chain given. Challenge students with the following; "If material (food) is moving in one direction in a food chain (producer to consumer), how is this material returned to the soil (cycled)?" Discuss the role of decomposers. Define decomposers as organisms that break down or decay once living things. Elicit that in doing this, they return materials to the soil for use again by green plants. Refer to this as an energy cycle.

    Revise the food chain on the board as follows:



17. If available, show a rotting log or refer to forest litter. Challenge students to suggest what happens to these materials in time. Elicit that they are decomposed. List examples of decomposers- bacteria, mushrooms (fungi), insect larvae.

Enrichment

For each of the following food chains, identify the producer and level of each consumer.

a) seeds → kangaroo rat → snake → bobcat
b) diatom → copepods → sardines
c) grain → field mouse → hawk
d) algae → protozoa → minnow → crayfish

Lesson 24 Food Chains-Lab Activity

Aim: How can we observe a food chain?

Materials

prepared mixed culture containing chlorella, paramecia, and Blepharisma (Mix before use), Daphnia, microscope, lens paper, cover slips, depression slides, medicine dropper, paper towel

Objectives

To observe the diversity of life in a water sample
To identify the members of a food chain
To observe the various feeding relationships in a water culture
To draw a diagram of a food chain or food web observed

Strategies

1. Elicit the definition of a food chain as a process or cycle in nature in which organisms are dependent upon each other for their food. Tell the students that in this lesson they will study a food chain that occurs on a microscope slide. Familiarize students with the organisms they will be viewing.
2. Review the proper care and use of the microscope.
3. Have the students prepare a depression slide of the prepared culture.
4. Circulate among the students as they perform the suggested activities.
5. At the end of the laboratory exercise, discuss the types of feeding relationships observed. Encourage students to develop a food chain based upon their observations.

LEVEL	EXAMPLE
Producer	Chlorella (green algae)
Primary consumer	Paramecium
Secondary consumer	Blepharisma
Tertiary consumer	Daphnia

6. Discuss the implications of disrupting a food chain. Elicit that if the balance is disturbed or disrupted, organisms may die.

STUDENT LABORATORY WORKSHEET

Lesson 24 How can we observe a food chain?

Name ______________________________ Date ___________ Section ___________

Introduction

Living things require food for survival. Foods provide living things with the energy needed to carry on life activities. Food also provides the raw materials necessary for the growth and repair of body tissues.

The energy in food comes from sunlight. Green plants have the ability to convert sunlight into the chemical bonds that hold a molecule of sugar together. Since green plants make food and oxygen, we call them producers. While most of us are aware of the many kinds of plants on land, it is interesting to note that most of the food production on the earth takes place in the oceans. In the water, microscopic plants known as algae and diatoms carry on photosynthesis.

Animals cannot manufacture food. They depend upon green plants for their food supply. For this reason, animals are referred to as consumers. If it were not for green plants, it is unlikely that animals could survive.

The transfer of energy can be traced from:
---the sun
---to plants
---to each of the animals that eat the plants
---to the animals that eat the animals that eat the plants

The connection or linkage between all of these organisms can be described as a food chain. In a natural environment, organisms have a varied diet so that there is actually a complicated series of overlapping food chains. These are referred to as a food web.

Materials

mixed culture
medicine dropper
depression slide
lens paper
Daphnia
microscope
cover slips
paper towels

Procedure

1. Place a drop of mixed culture on a depression slide. Use the medicine dropper to carefully add one Daphnia to the culture. Place a cover-slip on the slide and observe under low power.

2. Identify the organisms and note the activity of each. Record your observations on the student data sheet.

Post Lab Questions

1. What special feature(s) does each organism have that helps it obtain food?
2. Expand the observed food chain by indicating other organisms that eat each of the organisms observed.
3. What would happen if there was an overabundance of Daphnia present?
4. What would happen if the producer were destroyed?
5. Give an example of another simple food chain.

STUDENT DATA SHEET

Lesson 24 How can we observe a food chain?

Name ______________________ Date __________________ Section _________

Observations

Organism	Activity Observed	Role in Food Chain

Lesson 25 Food Webs and Food Pyramids

Aim: What relationships exist between different food chains?

Materials

food web chart (reproduced)
identification cards
ball of string

Preparation of Materials

Using 3x5 index cards, prepare one card of each of the following:

Front of Card	Back of Card
Green Plant	Makes Own Food
Rabbit	Eats Green Plant
Grasshopper	Eats Green Plant
Field Mouse	Eats Green Plant
Frog	Eats Grasshoppers
Snake	Eats Frogs, Grasshoppers
Hawk	Eats Snakes, Frogs, Fieldmice
Badger	Eats Mice
Fox	Eats Mice, Rabbits, grasshoppers
Deer	Eats Green Plants
Wolf	Eats Mice, Deer, Rabbits
Owl	Eat Rabbits, Mice

Objectives

To distinguish individual food chains in a food web
To understand the complex nature of the food web
To construct pyramid models of energy, mass and number relationships between the organisms in a food web
To analyze the relationships that exist within the model constructed

Strategies

1. At random, distribute the identification cards to students seated throughout the room. Inform the students that they will be using these cards and string to make a visual model of various food chains.

2. Using the cards and string, trace out an individual food chain. For example:

   green plant ⟶ grasshopper ⟶ frog ⟶ snake ⟶ hawk

3. Trace out a second food chain. For example:

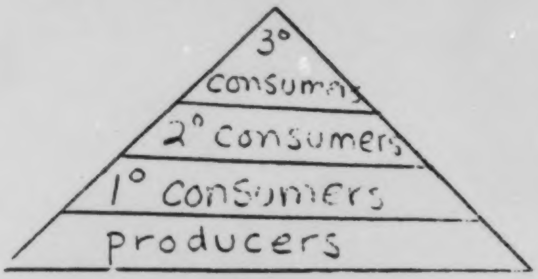
   green plant ⟶ mouse ⟶ wolf

4. Trace several food chains. After these have been constructed observe the overlapping and describe the web-like pattern established. Define a food web as interlinked or interconnected food chains. Elicit the complexity of a food web.

5. Elicit that the badger eats only mice while the fox eats mice, rabbits, and grasshoppers. Challenge students to explain what feeding advantage the fox might have over the badger. Elicit that if the mouse population dies out, so does the badger.

6. Elicit that in any food web, the producers must be the organisms present in greatest amounts.

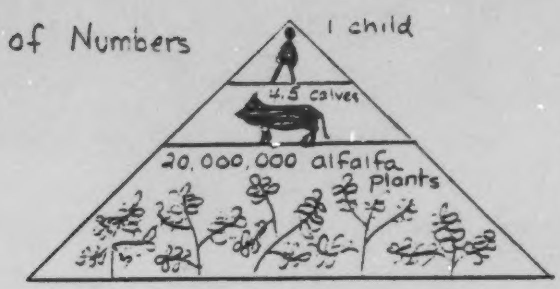
7. Place the following on the board.



Food Pyramid

Using the Food Pyramid as a guide, ask students if they would expect to find more rabbits than foxes in a food chain. Elicit that as you go up in feeding level, the number of organisms decrease. This is known as a Pyramid of Numbers.

Pyramid of Numbers

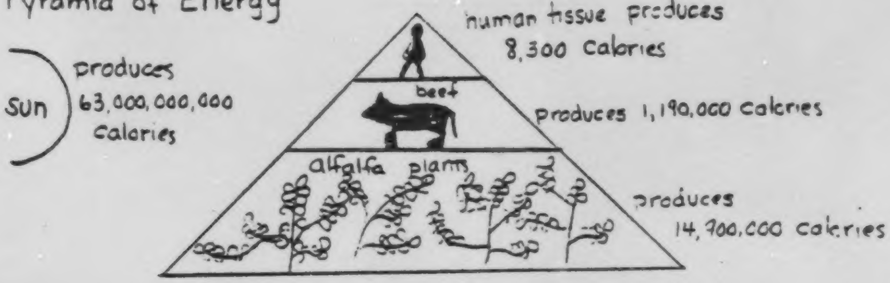

1 child
4.5 calves
20,000,000 alfalfa plants

8. Develop the following for discussion:

   Energy is in food molecules. If a rabbit eats 50 pounds of leaves a year, and a fox eats the rabbit, why doesn't the fox get all the energy stored in 50 pounds of leaves? Point out that as food molecules move along a food web, energy is used at each level. For example, when a rabbit eats a plant, some of the energy is used in the eating process, more energy and food molecules are used in making parts of the rabbit's body that are not eaten: fur, nails, teeth and bones.

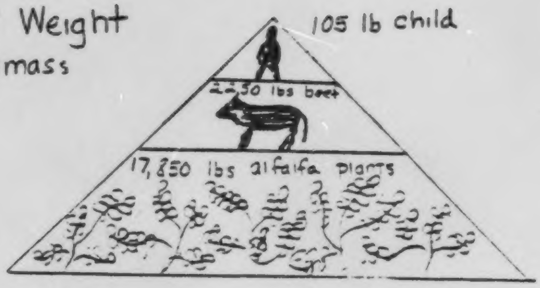
9. Have the class indicate the change in available energy as you move up the pyramid. Elicit that available energy decreases as you move upward.

Pyramid of Energy


human tissue produces
8,300 Calories
sun
produces
63,000,000,000
Calories
beef
produces 1,190,000 calories
alfalfa plants
produces
14,900,000 calories

10. Challenge students to determine why the weight (mass) of each higher feeding level would decrease. Elicit that by the time we reach the top of a pyramid, only a small percentage of the usable weight, or biomass is left.

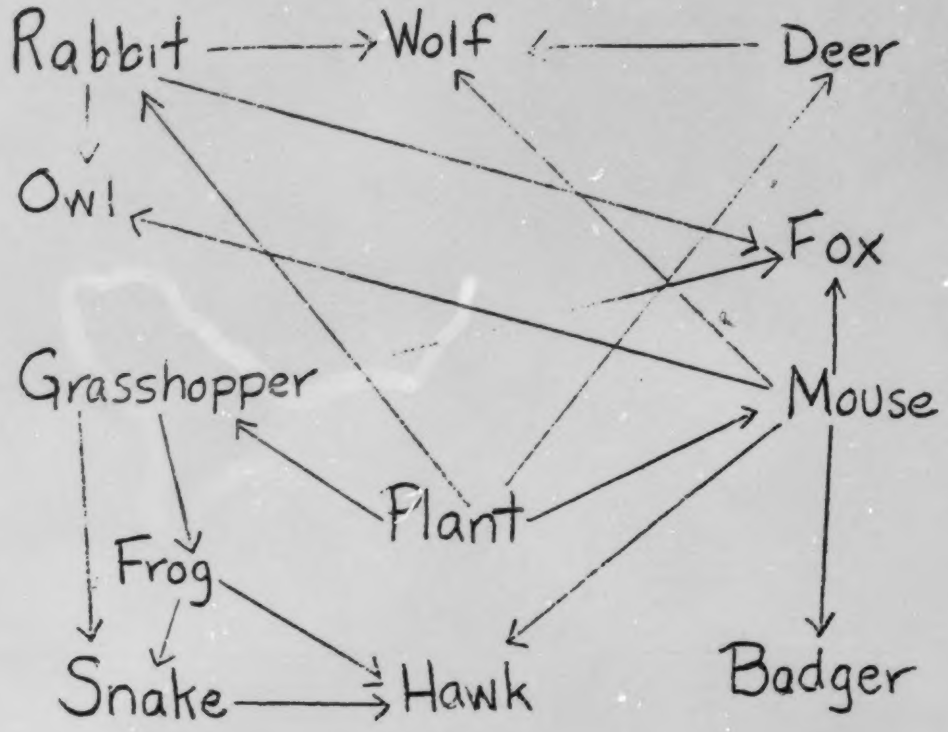
Pyramid of Weight
or Biomass


105 lb child
2,250 lbs beef
17,850 lbs alfalfa plants

Enrichment

1. Some environments have simple, direct food chains, while others have complex food webs. Which of these two environments would be more easily upset by the action - of people. Why might this be true?
2. Using the food pyramid, explain the statement, "All life is grass."

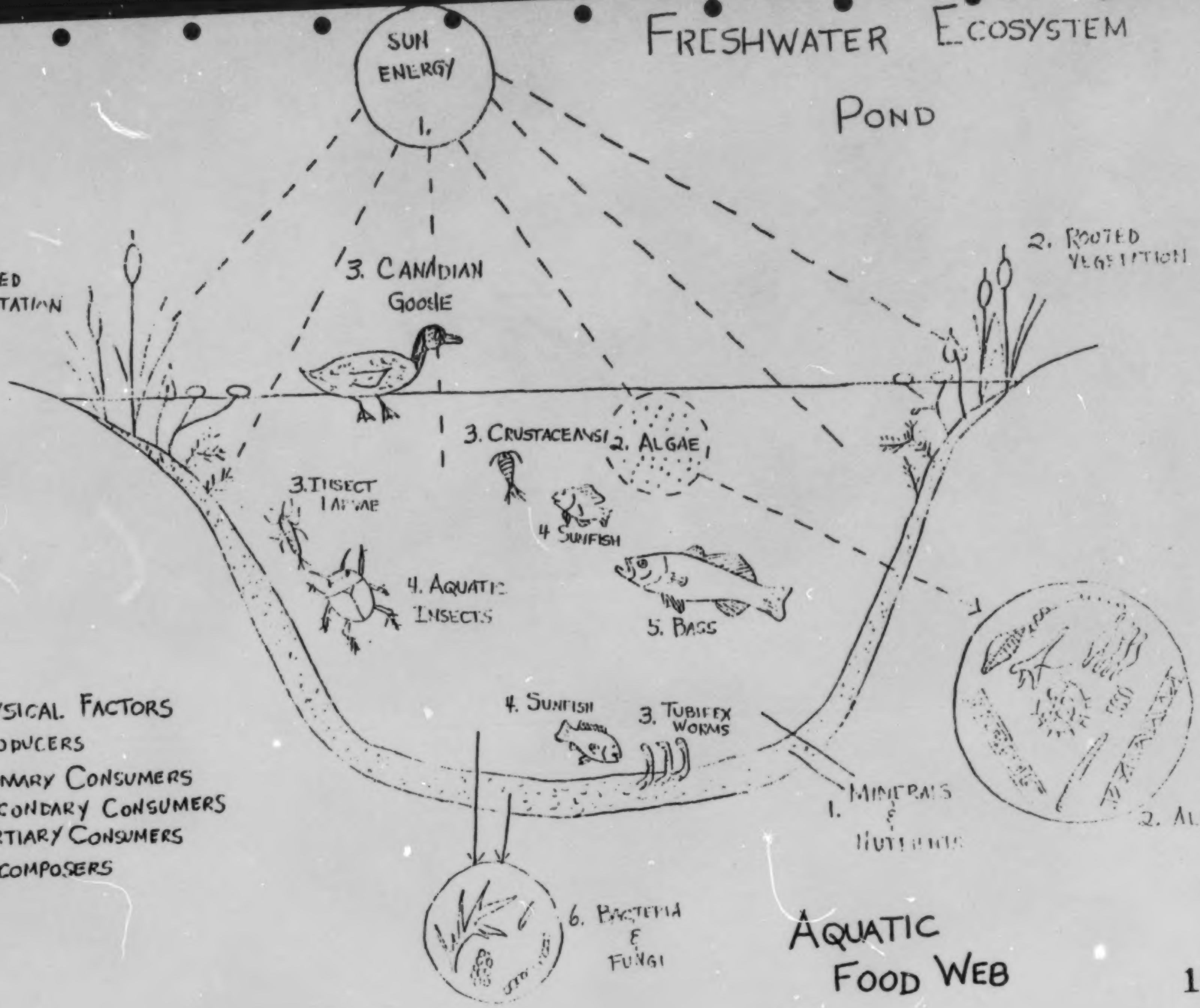
ADDITIONAL TEACHER NOTES


Rabbit
Wolf
Deer
Owl
Fox
Grasshopper
Mouse
Plant
Frog
Snake
Hawk
Badger

Terrestrial Food Web

FRESHWATER ECOSYSTEM

POND


SUN ENERGY
1.
2. ROOTED VEGETATION
3. CANADIAN GOOSE
2. ROOTED VEGETATION
3. CRUSTACEANS
2. ALGAE
3. INSECT LARVAE
4 SUNFISH
4. AQUATIC INSECTS
5. BASS
4. SUNFISH
3. TUBIFEX WORMS
1. MINERALS & NUTRIENTS
2. ALGAE
6. BACTERIA & FUNGI

1. PHYSICAL FACTORS
2. PRODUCERS
3. PRIMARY CONSUMERS
4. SECONDARY CONSUMERS
5. TERTIARY CONSUMERS
6. DECOMPOSERS

AQUATIC FOOD WEB

Lesson 26 Nutritional Relationships

Aim: What roles do organisms play in the food chain?

Materials Film loop or film showing feeding behavior

Objectives

To understand that every organism requires food to survive and will use various means to get it

To distinguish in every food chain organisms that are herbivorous (plant eaters), organisms that are carnivorous (meat eaters) and those that are omnivores (plant and meat eaters)

To understand that some organisms actively hunt for food (predators) while some wait for what's left over (scavengers)

To demonstrate that animals and plants will compete for food if necessary

Strategies

1. If possible show photographs of or describe wall paintings made by cave people. Elicit that these paintings serve as an account of the lives of these people. Ask the students to suggest how these people may have obtained food. Elicit that hunting was originally not a form of recreation but a means of survival.

2. Discuss predator-prey relationships. Define a predator as an animal that hunts for its food. Elicit that the prey is the animal hunted by the predator. As an example, discuss the kind of activity that might take place when a shark spots a fish. Elicit that the shark is the hunter or predator, while the fish is the prey. All predators hunt for their food.

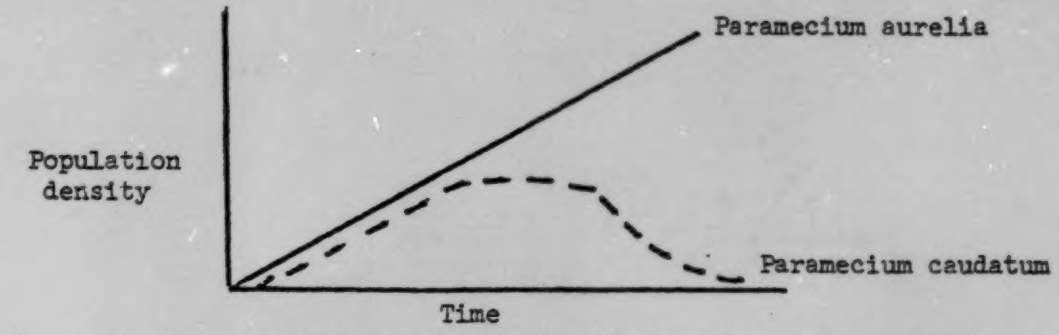
3. Discuss what might happen if the shark did not completely eat his meal. Elicit that other organisms would come along and eat the material that was left over. Define these organisms as scavengers. Elicit that scavengers are organisms that eat dead organisms. Vultures and hyenas are examples of well-known scavengers.

4. Develop the concept of competition. Ask students to consider what might occur if two gas stations open across the street from each other. What type of relationship might develop between the two? Develop that each station would be in competition with the other.

5. Define competition as a rivalry that takes place between two organisms for food, living space, nesting site, or shelter. Elicit what might happen if two animals are placed in a cage with only one bowl of food.

6. Elicit that competition may occur between members of the same species, (intraspecific), or between members of different species (interspecific).

7. Describe the experiments performed by Gauss using two species of paremecium. In these experiments, the population density was compared when Paramecium aurelia was allowed to live alone and when it was mixed with Paramecium caudatum. Paramecium caudatum was also studied when it lived alone. The following graph describes this relationship.



8. Elicit the possible effects of competition. Competition will:
    a) eliminate the weaker organism
    b) allow natural enemies to maintain a "balance of nature."

Enrichment

1. Give examples of predators and their prey.
2. Explain how competition could affect population size and help to preserve the balance of nature.

ADDITIONAL TEACHER NOTES

Lesson 27 Predator-Prey Relationships-Role Play Game

Aim: How do animals get the food they want?

Materials

3x5 index cards with a brief description of an organism

Preparation of Materials

a) Prepare 8 predator cards as follows:

Card 1	A four legged animal that eats burrowing animals	Card 5	A bird that eats small grass and leaf eating animals.
Card 2	A large fish that eats small algae-eating fish	Card 6	A climbing animal that eats small seed-eating birds.
Card 3	A bird that eats soft bodied animals that live in mud	Card 7	A small land animal that eats crawling insects.
Card 4	A bird that eats flying insects	Card 8	A four legged animal that eats grazing animals.

b) Prepare 8 prey cards as follows:

Card 1	A small furry animal that nibbles on leaves and grass and builds its nest in a hole or pile of leaves	Card 5	A soft bodied animal that lives in mud and feeds by filtering food particles from water
Card 2	Small flying insect that drinks nectar from yellow flowers	Card 6	A small seed-eating bird that nests in tall leafy trees
Card 3	A four legged grazing animal that eats grass in forest meadows	Card 7	A small fish that eats algae growing on brightly colored coral
Card 4	Small furry animal that burrows in the ground and eats roots	Card 8	A crawling insect that eats dead plants and animals

Objectives

To define predator-prey relationships
To discuss adaptations for survival
To allow students to demonstrate the ability of predators and prey to survive

Strategies

1. Review the definition of predator and prey. Define predators as animals that hunt other animals for food. Define prey as the hunted animals.

2. Refer to previous learnings. Challenge students to discuss how animals and plants are designed or adapted for their feeding habits. Elicit types of claws, teeth, beaks. Briefly discuss the root systems of various plants.

3. Ask how animals or plants may avoid being eaten. Have students **recall** such terms as mimicry, coloration, etc.

4. Elicit the general characteristics of a well-known predator or prey. How is each suited for its role in the community?

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 27 How do animals get the food they want?

Name ______________________ Date ______________ Section __________

Introduction

In all ecosystems most animals may be classified as either predators or prey, the hunters or the hunted. The purpose of this activitiy is to try to avoid being eaten if you are a prey and to catch the prey if you are a predator. In real life predators and prey have special adaptations that help them hunt or avoid capture. During this activity those of you who are predators will list adaptations which you feel are necessary to catch your prey. Those chosen to be prey will list adoptations they feel will help them avoid capture. Each group, predators and prey, will work separately. After you have listed the adaptations you feel you will need, predator and prey cards will be compared. If a predator has an adaptation to catch its prey that the prey has no defense for the predator will win.

Materials

predator-prey cards

Rules of Play

1. Your teacher will divide the class into two groups; predator and prey.
2. Choose a card, face down from the pile for your group.
3. Look at the description of the animal on the card and list your suggested adaptation on the back of the card. You will have ten minutes to complete this.
4. Your card will be compared to the card of your predator or of your prey.
5. Scoring: Score 1 point for each adaptation that cannot be overcome by the predator or prey. The person scoring the most points wins.

Lesson 28 Symbiosis

Aim: How do some organisms live together?

Materials

slides or photographs which illustrate a wide variety of symbiotic relationships

Objectives

To understand the advantages and disadvantages of symbiotic relationships.
To distinguish between free-living and parasitic relationships
To appreciate the effect of symbiotic relationships

Strategies

1. Elicit why people live together in a society. Guide students to the understanding that people have different roles in society. Elicit that there are both positive and negative relationships.

2. Discuss the role of protozoans in the digestive tract of termites. Elicit that termites eat wood, but that the protozoans help in the digestion of the material eaten. Explain that the termite provides a place for the protozoans to live. Who benefits from this type of relationship? Define mutualism as a relationship in which two organisms live together for the benefit of both organisms. Elicit and discuss other mutual relationships.

3. Discuss the fact that there are relationships between organisms in which one of the organisms is not affected. Define this type of relationship as commensalism. Explain that only one organism benefits in a commensal relationship. The other is not affected. Elicit and discuss other commensal relationships.

4. An example of a commensal relationship is one that exists between the remora fish and a shark. The remora lives attached to the side of the shark. It eats small scraps of food left over by the shark.

5. Discuss the relationship of ticks or worms and dogs. Explain that ticks or worms may live on or in the body of the dog. The ticks and worms get what they need to stay alive from the dog. They give nothing in return. This type of relationship is called parasitism. Ticks and worms are the parasites. The dog is the host. Elicit how parasitism may affect the host organism. Only the parasite benefits from this type of relationship. The host organism is often harmed.

6. Elicit such other parasitic relationships as disease causing bacteria, fungi causing atheltes foot, protozoa which cause malaria, and tapeworm.

Enrichment

1. Give examples of some symbiotic relationships which may take place in the human body.
2. Describe how parasites are adapted for their way of life.

ADDITIONAL TEACHER NOTES

Lesson 29 Habitats

Aim: Where do organisms live?

Materials

terraria
pictures, film strips illustrating various habitats

Objectives

To discern the factors that determine the habitat of an organism
To understand that organisms live in only a small area of their habitat known as a home range
To appreciate territorial behavior in an organism

Strategies

1. Elicit from students where they would have to go to locate each of the following organisms in their natural environment: penguin, deer, cactus, flounder, buffalo, polar bear. List the responses on the board. Explain that each of the places referred to is a habitat. Define habitat as the environment in which an organism lives.

2. Elicit biotic and abiotic factors that might determine where an organism lives. Included among these factors might be food, water, living space, humidity and a proper temperature.

3. Ask students what might affect such factors as food, water, and living space in a particular habitat? Elicit that there will be competition among members of the same species for these factors. Define this as intraspecific competition.

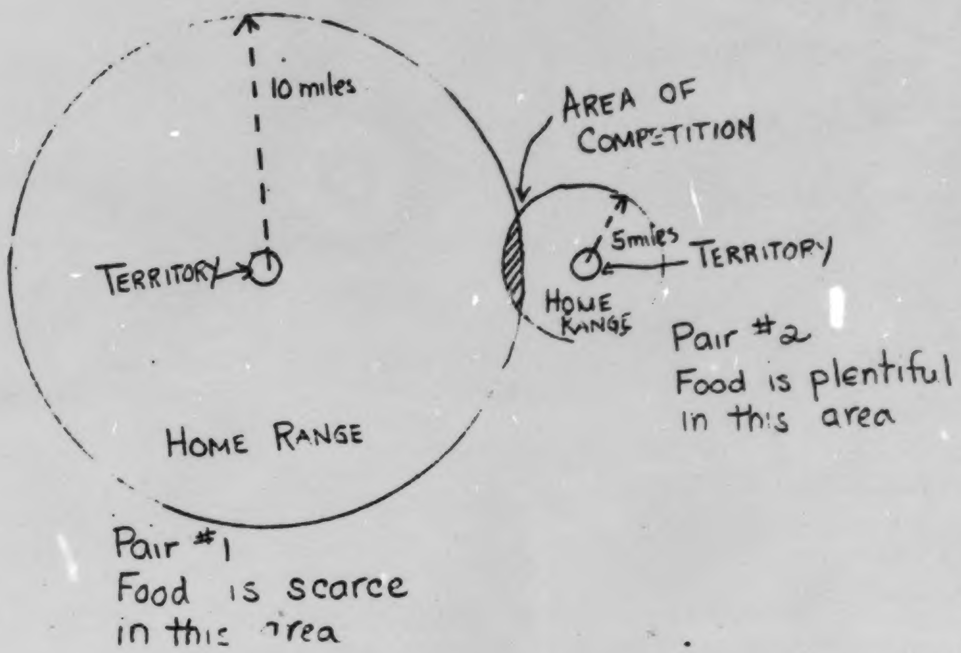
4. Ask students to explain why all the birds in a forest do not occupy the same tree. In other words, why must they spread themselves out and occupy many trees? Elicit the limited availability of food, nesting sites and materials, mates, etc.

5. Develop the following concept. Each bird or pair of birds, has its own area in which it lives. This area is known as its home range. The birds eat, sleep and rear their young in their home range.

6. How would birds indicate to other birds that a particular home range is theirs? Elicit that this is believed to be the function of many birds' songs.

7. Develop the fact that usually, a small part of the home range, near the nesting site, is actively defended. This is especially so during the breeding season. Animals may fight to the death to protect this small area. Define the small area as a territory.

8. The following illustration represents the home ranges and territories of two pairs of hawks.


10 miles
AREA OF COMPETITION
5 miles
TERRITORY
TERRITORY
HOME RANGE
Pair #2
Food is plentiful in this area
HOME RANGE
Pair #1
Food is scarce in this area

What types of activities may occur inside the territory of each pair of hawks? inside the home range? Why is the home range of pair #1 so much larger than the home range of pair #2? What will occur inside the shaded area?

9. Very often, animal pets exhibit territorial behavior. Elicit student experiences in this. For example, ask students who have dogs to explain the dog's behavior when someone rings the bell.

Enrichment

1. Bears have been known to mark trees by scratching them with their claws. What do you suspect is the purpose of such behavior?

2. Describe your home range and territory. How was it set up? How is it maintained?

Lesson 30 Niche

Aim: How do organisms live, function, and eat?

Materials

classroom terrarium and/or aquarium

Objectives

To realize the many different jobs an organism plays in a community and the interdependence that results from it

To be able to draw a conclusion on the effects of competition

Strategies

1. Encourage students to observe communities in a terrarium and/or aquarium. Have them list the organisms they observe.

2. Challenge students to determine the advantage of having many different organisms in a community. Elicit that the greater diversity allows for a diversity of foods and habitats. For example, in an aquarium, there may be fish, snails, algae, and large multicellular plants such as Elodea. Elicit the functions performed by the plants; e.g., making foods and oxygen. Elicit also that Elodea may serve as a living place for small fish and that algae serve as food.

3. Explain that the jobs performed by an organism are referred to as its niche. Define niche as the role of an organism in an ecosystem. Ask students to list the niches that are filled by other organisms in the terrarium/aquarium.

   Elicit that some of the organisms play similar roles in the community, but that no two organisms occupy exactly the same niche. The roles are similar but not identical because two organisms cannot occupy the same niche for any great length of time.

4. Explain that it frequently happens that a new species is introduced into an environment. This new species may have the same niche as another organism already in the environment. Elicit that possible consequences of competition might result in:

   a) one organism completely eliminating the other
   b) the two species taking over different parts of the niche (niche splitting)

5. As an example of niche splitting, students may want to consider the roles of various family members. All live at the same address (habitat), yet all have different family roles: e.g., to work to provide money, to cook, to clean the house, to care for children, to be a student. Each member has a particular niche.

6. Elicit from students as many types of organisms they can think of that occupy a desert habitat. Have students explain the job or niche of each in the ecosystem.

    scorpions - 2° consumer - insects - live in shade

    roadrunner - 2° consumer - lives in shade, preys on insects, lizards, rattlesnakes

    lizards - 2° consumer - insects, live in burrows

    rattlesnakes - 2° consumers - live in burrows, preys on rodents such as:

      -ground squirrel - 1° consumer - plants

      -kangaroo rat - 1° consumer - plants

      -insects - 1° and 2° consumers - plant and animal (parasites)

    desert plants - cactus - producer - water storage - produce seeds that serve as food

    mesquite - producer - seeds are food for animals

    creosote - producer - it is not eaten by animals because of taste.

7. Elicit from students that although there are many 2° consumers, they all have a different niche because they prey on different organisms. Even those that prey on insects will eat only certain kinds of insects, and they live in a different place.

Enrichment

1. Show a film or filmstrip about the organisms of the desert.
2. Discuss the adaptations of "Darwin's Finches" into the many niches on the Galapagos Islands.
3. List the organisms found in a neighborhood park or building. Describe the niche of each.

UNIT IV

STRUCTURE OF THE ECOSYSTEM

An understanding of the dynamic nature of an ecosystem is basic to an understanding of ecology. Unit IV is designed to introduce the student to the complex organization of the ecosystem. Students are encouraged to analyze the biotic and abiotic components of various ecosystems. The concept of ecological succession is introduced as is the role of plants, animals, microorganisms, and weathering in the formation of soil.

Major world biomes are compared with respect to life forms and limiting factors. An application of student understanding comes about in the culminating activity. In this, students are asked to design and construct a mini-ecosystem.

Lesson 31 Properties of Water

Aim: What are some properties of water?

Materials

50 ml tap water
50 ml hard water
2- 100 ml beakers
bunsen burner
benzene
5 test tubes
potassium permanganate
glass stirring rod
2 tripods
wire gauze
safety matches
2 thermometers
oil
test tube rack
ethyl alcohol
sand

Preparation of Materials

Hard water may be prepared by adding a large amount of any soluble salt to tap water.

Objectives

To understand the physical and chemical properties of water
To measure the temperature of a water sample
To understand that water may contain a variety of other substances
To observe how a solid will affect the heating and cooling rate of a liquid

Strategies

1. Elicit some of the properties of water. Included among the responses should be that water is a colorless, tastless, odorless liquid at room temperature. Elicit also the chemical composition of water; i.e., two atoms of hydrogen combined with one atom of oxygen.

2. Set up the tripods and beakers. In one beaker, place 50 ml of tap water. In the second beaker, place 50 ml of hard water. Heat both water samples to boiling. Record the temperature of each. Allow the water in each of the beakers to evaporate completely.

3. Have the students observe the contents of each beaker. How do they compare?

   Elicit that water contains dissolved minerals. Soft water contains little or no minerals; hard water contains large amounts of dissolved minerals. From this demonstration, elicit that another property of water is that it can dissolve certain materials.

   Establish that dissolved minerals affect the boiling point of water.

4. Do solids mix with liquids? Demonstrate the solubility characteristics of water compared to that of benzene and oil. Set up three test tubes and add water, benzene, and oil respectively. Place a small amount of potassium permanganate in each of the liquids. Define solubility as the ability of one substance to dissolve in another. Elicit the solubility of potassium permanganate in each of the three liquids.

5. Do liquids mix with other liquids? Fill two test tubes half-full with water. Place a small amount of oil into one. Place a small amount of ethyl alcohol into the other. Students should observe that the water and alcohol mix, while the water and oil do not.

6. Do gases mix with liquids? To illustrate the solubility of gases in water, discuss carbonated water. Elicit that carbonated water contains carbon dioxide gas dissolved in water. You may also want to discuss dissolved gases in the blood.

   Establish that fish obtain oxygen from dissolved oxygen in the water. Define dissolved oxygen as oxygen gas that is mixed with water.

7. How does temperature affect solids and liquids? Heat equal sized samples of sand and water in beakers set up on tripods. Record the temperature of each after 5 minutes. Mix each sample with a stirring rod as it heats. Set aside and record the temperature 5 minutes later.

   Which heated up more quickly? Which cooled more quickly? Why?

Enrichment

Describe what happens when you try to wash your hands with salt water and hand soap.

Lesson 32 Freshwater vs. Saltwater-Lab Activity

Aim: How may water samples differ?

Materials

jar containing fresh water	balance
jar containing brackish water	25 ml graduated cylinder
jar containing salt water	hydrometer (if available)

Objectives

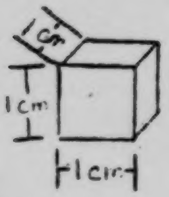
To determine the differences between fresh, brackish, and salt water
To determine the density of water samples
To determine the effect of salinity on the boiling and freezing point of water

Strategies

1. Display the samples of fresh, brackish, and salt water. Based upon a visual inspection, challenge the students to determine whether the water samples are the same. Elicit that visual inspection is not enough to determine differences between water samples. Explain that various methods may be used to determine differences in water samples.

2. Challenge students to explain how they might determine differences in water samples. Elicit that the density of a liquid is an important property and that it can be used to help identify liquids.

   State that the density of water is 1 g/cm^3. Explain that 1 cubic centimeter of water equals 1 millileter of water equals 1 gram of water.



1 cubic centimeter

cm^3

$1 cm^3\ H_2O = 1\ ml\ H_2O = 1 g\ H_2O$

3. Use a 25 ml graduated cylinder. Weigh a 10 ml sample of fresh water and a 10 ml sample of mercury. Determine the density of each. Have students note the difference.

4. Distribute the student laboratory sheet and materials. Students are asked to determine the density of 100 ml samples of fresh, brackish, and salt water. If available, use a hydrometer to verify their results. Explain that a hydrometer measures density by the buoyancy of the liquid. The more dense the liquid, the greater its buoyant properties, the higher the hydrometer will float.

5. In the last part of the student activity, students are asked to determine the boiling point for each of the three water samples as well as the time it takes for the samples to boil. If time and facilities permit, freezing point and time for freezing should also be determined.

Optional

6. If students are to perform Procedure 8, a supply of dry ice should be made available.

Enrichment

Explain why the water in the lower New York bay is brackish.

STUDENT LABORATORY WORKSHEET

Lesson 32 How may water samples differ?

Name ____________________ Date ______________ Section __________

Introduction

Fresh water is sometimes called "sweet water" because it contains very little dissolved salt. Ocean water is salty because it contains salt washed into it by rivers. In areas around the coast, especially near the mouth of a river, fresh water and salt water mix to form brackish water.

As salt is added to water, it changes certain characteristics or properties of the water. In this laboratory exercise, you will determine some differences between fresh and salt water.

Materials

3-250 ml beakers
100 ml graduated cylinder
sample of fresh water
sample of sea water
bunsen burner
clock with sweep second hand
safety matches
marking crayon
balance
sample of brackish water
tripod or ringstand
wire gauze
student data sheet
thermometer

Procedure

1. Label the beakers A, B and C.
2. Weigh each of the beakers and record the weight on the student data sheet.
3. Place exactly 100 ml of fresh water into beaker A. Weigh the beaker and water sample. Record the weight on the student data sheet.
4. Place exactly 100 ml of brackish water into beaker B. Weigh the beaker and water sample. Record the weight on the student data sheet.
5. Place exactly 100 ml of salt water into beaker C. Weigh the beaker and water sample. Record the weight on the student data sheet.
6. Calculate the density for each of your samples. Use the formula:

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

Enter the density on the data sheet.

7. Heat each of the beakers over the bunsen burner. For each, record the boiling temperature and the time it takes to reach the boiling temperature. Enter your results on the data sheet.

Optional

8. If time and materials permit, determine the freezing temperature and the time it takes for each of the water samples to freeze. Enter your results on the data sheet.

9. After you have completed collecting your data, clean and return the materials.

Questions and Conclusions

1. What may affect the density of different water samples?
2. How does salt affect the boiling point of water?
3. How does salt affect the time it takes for water to boil?
4. When cooking spaghetti or potatoes, people often place salt in the water. Explain why.
5. Salt is used during the winter to melt ice. What effect do you think salt has on the freezing point of water?
6. Why do some rivers and lakes freeze during the winter while oceans do not?
7. How does salt affect the density of water?

STUDENT DATA SHEET

Lesson 32 How may water samples differ?

Name ______________________ Date ______________ Section ________

I. Density Determination

	BEAKER		
	A	B	C
Weight of beaker			
Weight of beaker and sample			
Weight of sample			
Density of Sample			

II. Boiling Temperature and Time

	BEAKER		
	A	B	C
Boiling Temperature °C			
Boiling Time			

III. Freezing Temperature and Time (optional)

	BEAKER		
	A	B	C
Freezing Temperature °C			
Freezing Time			

Lesson 33 The Ocean Environment

Aim: What are some features of an ocean environment?

Materials

world map or globe

Objectives

To identify the ocean environment and its location in reference to the continental shelf
To identify the zones of the ocean
To understand the availability and the need for light in the ocean
To identify various life forms in the ocean and their interrelationship

Strategies

1. Refer to a world map or globe and develop a class discussion of the oceans. Elicit that the ocean waters cover approximately 70% of the earth's surface.

2. Challenge students to suggest the direction and/or location of the Atlantic Ocean in relation to New York City. Elicit that the Atlantic Ocean borders the eastern coast of the United States.

3. Ask students to describe how the water in the Hudson River differs from the Atlantic waters. Explain that an estuary is an area where the waters of a river and a sea meet. Elicit that the waters in an estuary are usually brackish; they contain a mixture of fresh and salt water. Explain that the lower New York Bay is an estuary. Elicit that the Hudson River has brackish water for many miles upstream.

4. Tell the students that for purposes of study, scientists divide the ocean into zones according to the amount of available light.

   Describe the photic zone as a zone having light. State that this zone extends downward from the surface to a depth of about 76 meters.

   Describe the aphotic zone as a zone having little or no light. From 72 to 182 meters, there is dim light. From 182 meters to the bottom there is darkness.

   Establish the relationship between light and depth. Elicit that as you do down, the amount of light decreases.

5. Ask students to suggest the types of organisms that might inhabit the photic and aphotic zones. Elicit that tiny plants and animals (plankton) live on or near the surface of the water. Phytoplankton (tiny floating marine plants) are also found in the photic zone. Many are usually found floating on the surface.

6. Explain that free-swimming animals (nekton) inhabit many levels of the ocean's depths whereas bottom dwellers (benthos) live in the deep ocean waters.

7. Challenge students to suggest feeding relationships of organisms that inhabit the depths of the ocean. Elicit that scavenging and predation are the most common feeding methods of these ocean inhabitants.

8. Challenge students to describe several food chains that might exist in the ocean zones.

Enrichment

1. Give five examples of ocean food chains.
2. Describe a food web of the ocean.

ADDITIONAL TEACHER NOTES

Lesson 34 The Shore Environment

Aim: How does the shore differ from the deep ocean?

Materials

pictures of various shorelines
pictures of a salt marsh community

Objectives

To compare the shoreline to the deep ocean
To understand the effect of tides on the shoreline
To examine the shore community
To understand the adaptation of organisms along the shore
To determine the importance of the intertidal zone and the salt marsh
To examine the factors responsible for beach formation

Strategies

1. Ask students to visualize and describe the ocean shore. Elicit that shores may be sandy, granular (graveled), rocky, shelled, or a combination of several of these. Display pictures of various shorelines to illustrate the variety of shore types.

2. Elicit the names of some organisms that are commonly found along the shore. Student responses should include such organisms as snails, barnacles, mussels, and crabs.

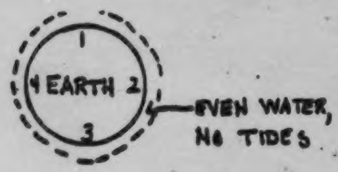
3. Ask students if the same amount of beach is always visible during a 24 hour period. Elicit that there are times when part of the shore is covered with water and other times, when it is dry. Define this area of the beach as the intertidal zone.

4. Challenge students to account for the existence of an intertidal zone. Establish that tides are periodic or rhythmic changes in the surface level of the ocean's waters. Explain that each day, there are two high tides and two low tides. In addition, each month, the highest high tide and the lowest low tide (spring tides), occur on the days of the new and full moon.

5. Challenge students to explain the cause of tides. Develop the understanding that the force of the earth's gravity tends to hold the ocean waters down, i.e., it would maintain a constant surface level. However, the moon and sun also exert a gravitational pull on the earth's waters. This pull is responsible for the tides. Explain that the tides change as the lunar day changes (about 52 minutes each day). Spring and neap tides are caused by the combined effect of the sun and the moon.

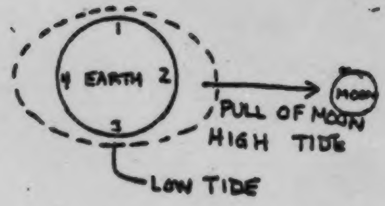
The following illustrations may be helpful.

A.

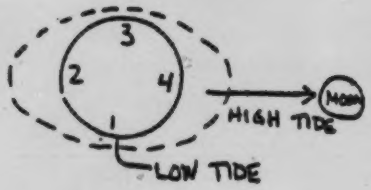

1
4 EARTH 2
3
EVEN WATER,
NO TIDES

IF THERE WERE
NO MOON,
NO SUN

B.


1
4 EARTH 2
3
MOON
PULL OF MOON
HIGH TIDE
LOW TIDE

C


3
2
4
1
MOON
HIGH TIDE
LOW TIDE

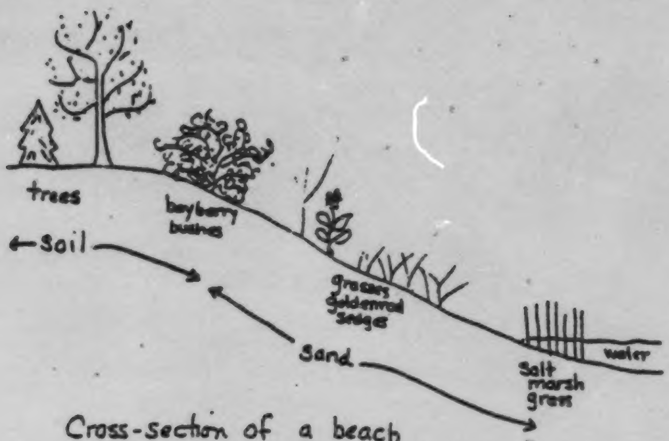
12 HOURS LATER

6. Elicit that organisms living in the tidal zone must possess special adaptations for the changes that regularly take place in this zone. For example, barnacles have a shell that can close. Crabs have appendages for digging holes in the moist sand.

7. Use pictures to illustrate the importance of a salt marsh community. The salt marsh is a protected nursery for young organisms and the salt marsh grass is highly productive.

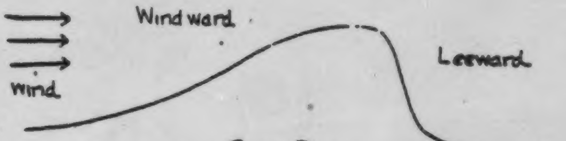
   Elicit student opinion as to whether salt marshes should become protected areas as opposed to building sites for the development of housing and shopping centers.

8. Sketch a cross-section of a beach on the board.



Cross-section of a beach

Ask students to describe the movements of sand on a windy day. As an example, ask what might happen to a large piece of wood on the beach. Where would most of the sand be deposited? Describe the formation and shape of a sand dune.



Sand Dune

9. Elicit what might happen to a blade of grass that started to grow on a sand dune. Explain that in time, the decay of dead grass begins to enrich the sand and builds soil. As the soil becomes enriched, other plants might grow on the sand dune. How might ocean winds affect plants along the beach?

10. Elicit how plants in a salt marsh or at the beach may differ from garden plants. Guide students to an understanding that salt spray necessitates an adaptation such as a thick, protective, waxy cuticle and special salt-excreting glands. These adaptations help shore plants survive.

Enrichment

1. What are waves? How are they responsible for building and eroding beaches?
2. Wooden fences are often put up on a beach. What is the purpose of these?

Lesson 35 Freshwater Ecosystems

Aim: What makes up a freshwater ecosystem?

Objectives

To identify sources of freshwater in ponds, lakes, rivers, streams, bogs, marshes, swamps, springs, and brooks
To determine the abiotic conditions in freshwater ecosystems
To identify relationships among the organisms that live in the freshwater ecosystem

Strategies

1. Review the hydrologic cycle. Elicit and discuss the role of evaporation, condensation, precipitation, and runoff as sources of fresh water.

2. Fresh water is found in rivers, streams, brooks, bogs, lakes, ponds, marshes, groundwater, underground streams, swamps, and springs.

   Point out that rivers and oceans meet in estuaries where salt and fresh water mix. The salt water usually mixes with river water for many miles upstream.

3. Elicit that abiotic factors present in various types of fresh water include:
   a) oxygen-(dissolved oxygen) from algae and other aquatic plants
   b) carbon dioxide- dissolved from animal and plant respiration
   c) nitrogen- ammonia is excreted by animals as waste, and is also a product of decay
   d) phosphates- are the product of decay

   Discuss the need for each of these materials by the living inhabitants.

4. Discuss the effects of temperature changes on fresh water. Explain that compared to land, water heats up slower and retains its heat longer than land. As water cools, it contracts and becomes heavier (as do other liquids) but at 4° C it begins to expand and becomes lighter as it solidifies at 0° C. Ice first forms at the surface of a lake. Why is this important for organisms living in the lake?

5. Discuss the physical differences between freshwater ecosystems, running-water habitats, and still-water habitats.

   Elicit that lakes and ponds are temporary structures found on inland depressions which contain still water. Lakes contain outlets. They also vary greatly in size.

The marsh and swamp begin along the shallow margins of lakes and ponds, or on poorly drained land. Marshes are wetlands characterized by reeds, sedges, grasses, and cattails, while swamps are wooded wetlands.

Bogs are characterized by poor drainage, cushion-like vegetation, and an accumulation of peat. Sphagnum moss is a typical organism.

Streams, springs, and rivers all are characterized by changes as they move downstream. There are changes in size, depth, velocity, and nutrient levels.

6. Elicit the following as organisms which are typical aquatic inhabitants.
   a) Producers- algae, rooted vegetation, phytoplankton
   b) Primary Consumers- insect larvae, crustaceans, worms, birds
   c) Secondary Consumers- small fish
   d) Tertiary Consumers- large fish
   e) Decomposers- bacteria, fungi

   Establish that these organisms make up a freshwater ecosystem.

Enrichment

1. Explain how the addition of chemicals and/or sewage might affect a freshwater ecosystem.
2. What is hibernation? How might temperature changes in a lake or pond affect the organisms which live there?

Lesson 36 Pond Succession

Aim: How does a pond age?

Materials

beaker of pond water, beaker of algae-filled water, beaker of muddy water

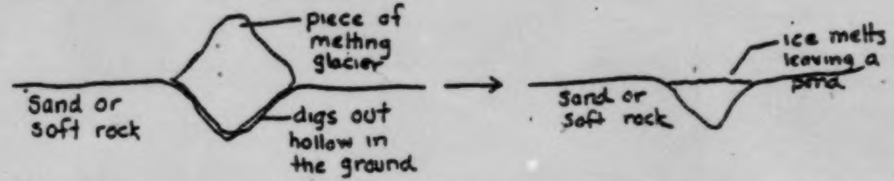
Objectives

To be able to understand the aging process in ponds
To be able to appreciate the role of abiotic factors in the aging process
To recognize features in ponds of different ages

Strategies

1. Elicit the definition of a pond. Explain that a pond is a still body of water that is usually smaller than a lake. Hold up the beaker of pond water. Ask students to explain how a pond may form.

2. Describe the formation of a glacial pond. The following illustration may be used.



Elicit that as glacial ice moves, large pieces of ice may break off and dig or gouge out a hollow in the ground. An isolated body of still water or pond results as the ice melts and the hollow is filled.

3. Elicit that as a result of this type of pond formation, very few (if any) organisms would be present. Yet, many ponds contain a variety of organisms. Challenge students to explain how this might occur.

   Develop the following:
   a) Animals and winds disperse spores, seeds, and eggs. These may eventually become deposited in the pond.
   b) Several ponds may interconnect and feed into one another.
   c) Streams or brooks may enter the pond.

4. If you examined a young pond for plants and animals, how many do you think you would find? Would they be of the same kind, or different?

Elicit that there might be many different types of organisms but that there would only be a few members of each type. This might be explained by the fact that there is not enough food available in a young pond to support a large population.

5. Display the beaker containing the algae-filled water. Ask students to account for the color of the water.

6. Challenge students to explain what might occur on the bottom of a pond as the pond grows older. Elicit that as the pond ages, a greater variety and number of organisms are introduced. As these age and die, an ooze forms at the bottom of the pond. Define ooze as a thin layer of soft mud that builds up on the bottom of bodies of water. Explain that this mud is very rich in dead plant and animal material, and is a source of materials for plants and animals that live in the body of water.

7. Display the beaker of muddy water. Elicit the relative age of the pond this water might have come from.

   Explain that an old pond has a thick layer of sediment (ooze) on the bottom.

8. Summarize pond succession by developing the following table on the board.

Age	Types of Organisms	Number of Each Type	Bottom
Young	Many new, different types	Very few of each type	Sandy or rocky, little or no ooze, deep
Middle-age	Not as many different types- competition for food kills off some types of animals	Large numbers of the types left	Getting shallow, ooze builds up as organisms die
Old age	Very few species of plants and animals	Large numbers of each. Especially algae that use nutrients from ooze	Very shallow, muddy bottom, covered with a thick layer of ooze

9. Define the term eutrophication as the succession, or aging of a fresh-water ecosystem.

10. Elicit that as the pond gets older. it completely fills with ooze. Define a swamp or fresh-water marsh as the remains of a pond or lake that has been filled from the bottom with ooze and mud. Explain that it is in the process of becoming solid ground again.

11. With the class, briefly trace the fate of a swamp or freshwater marsh as follows:

$$\begin{array}{ccccc} \text{swamp} & \longrightarrow & \text{meadow} & \longrightarrow & \text{forest} \\ \text{(marsh)} & & \text{(grass)} & & \text{(trees)} \end{array}$$

Enrichment

Explain the statement, "Life is responsible for the death of a pond".

ADDITIONAL TEACHER NOTES

Lesson 37 Land Formation

Aim: How is the surface of the earth built up?

Materials

pictures, charts, etc. showing volcanoes, river deltas, alluvial forms, glaciers, ammonium dichromate volcano, stream table or long tray containing a mixture of sand, pebbles, and soil, water source, safety matches, magnesium ribbon, map of Long Island (reproduce for distribution)

Preparation of Materials

Use Plaster of Paris to prepare a model volcano. Fill the crater of the volcano with ammonium dichromate. Use a piece of magnesium ribbon as a fuse to help ignite the ammonium dichromate.

Objectives

To analyze the geological processes involved in land formation

To be able to recognize the dynamic nature of geological processes

To be able to understand the role of people in land-forming processes

Strategies

1. Relate the following story to the class:

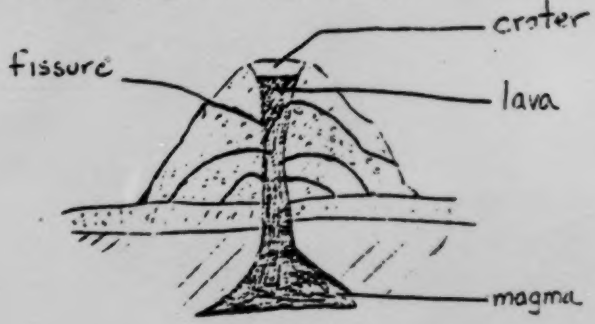
   In 1943, a Mexican farmer woke up one day and saw the following happening in his field... (light the model volcano)

2. Elicit a description of what has taken place.

3. Show some pictures of volcanoes.

4. Have students discuss volcano structure, lava flow, ashes, etc.

   Place the following on the board:



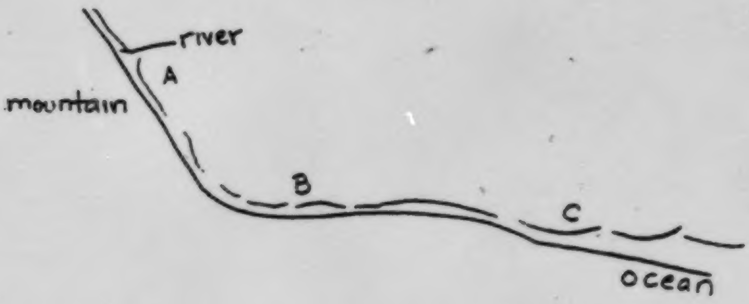
5. Define:
   magma- molten rock beneath the earth's surface
   lava- molten rock on the earth's surface
   crater- central opening of a volcano
   fissure- crack on the side of a volcano

6. Ask students to explain how volcanoes shape the land. Discuss primary land formation as the addition of new material to the crust of the earth from the earth's interior. As an example, refer to the Hawaiian Islands and the Volcanic Island Circle which is a new island off the coast of Iceland.

7. Elicit how moving water can help build up new land. Use the stream table, or tray with pebbles, sand, and soil to show how materials can be transported and deposited by water.

8. Define load as the material carried by a river. These materials include rocks, gravel, sand, and mud.

9. Place the following diagram on the board:



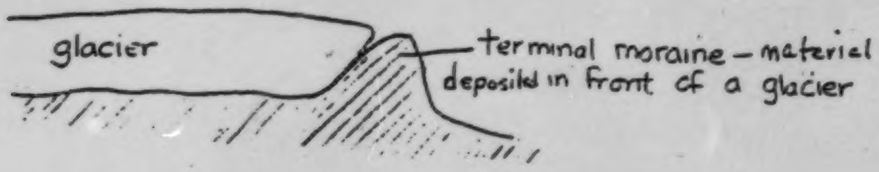
Use the diagram to elicit the following:
The point at which the-
- river flows fastest - A
- river flows slowest - C
- river can pick up the most material - A
- river can hold the least material - C

10. Have students determine the places where each part of the river's load might be dropped. Ask how the weight of these materials could be used to classify them.

11. Use pictures of river deltas and discuss delta formation. Define delta as a triangular deposit usually formed at the mouth of a river.

12. Ask students to imagine having lived 10,000 years ago, when the last great glacier covered New York. Describe the glacier as a mountain of ice more than 800 meters thick. As the glacier moved along the soft earth, what might form ahead of it?

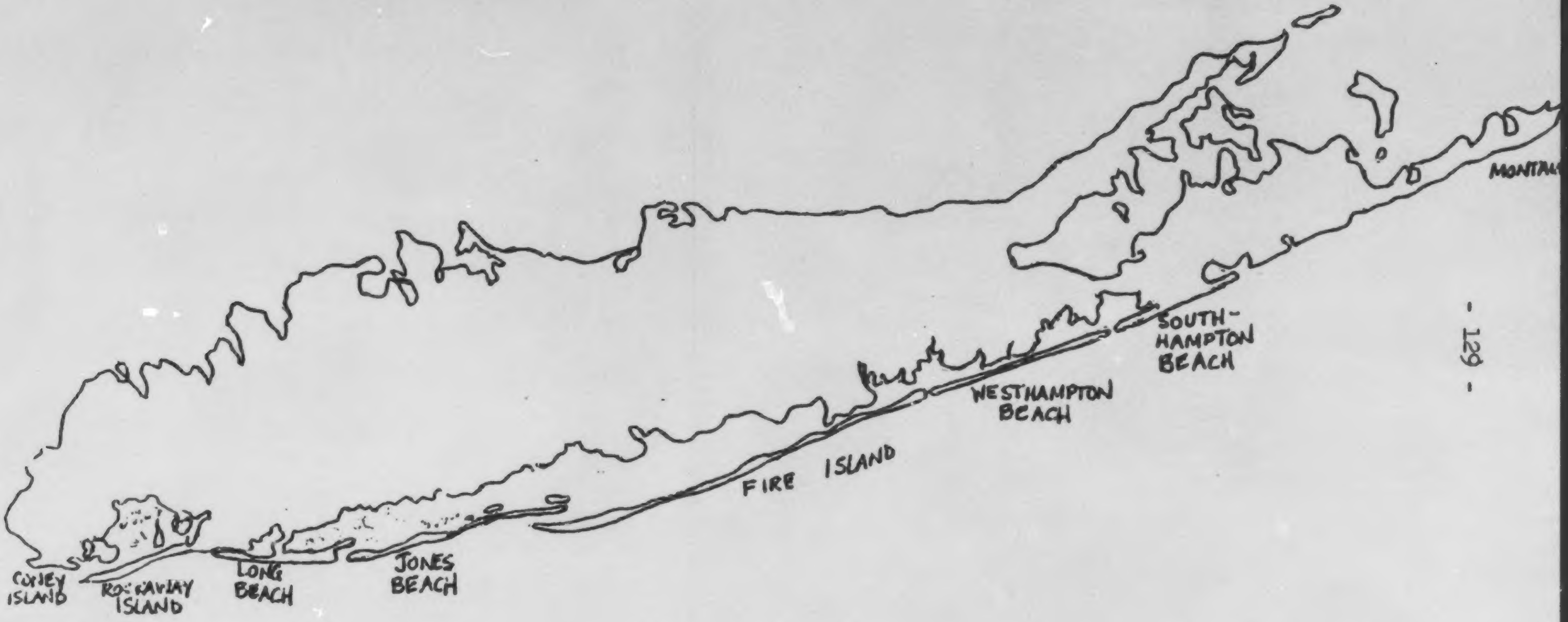
    Use pictures of a glacier to illustrate the appearance of a glacier. Discuss the formation of a terminal moraine. The following diagram illustrates the formation of a terminal moraine.



13. Distribute the map of Long Island. Use the map to illustrate the formation of barrier islands. Discuss the formation of a barrier island. Ask students what they think will happen when waves wash sand from the beach.

14. Discuss the role of people in forming new land. Discuss land filling techniques as a means of having layers of garbage and sand, or soil. Areas of New York City such as: Starrett City, Brooklyn, Pelham, in the Bronx, and Battery Park City in Manhattan are land-fill areas.

ADDITIONAL TEACHER NOTES


CONEY ISLAND
ROCKAWAY ISLAND
LONG BEACH
JONES BEACH
FIRE ISLAND
WESTHAMPTON BEACH
SOUTH-HAMPTON BEACH
MONTAU

LONG ISLAND AND BARRIER BEACHES

Lesson 38 Succession in Terrestrial Ecosystems

Aim: What are the features of a terrestrial ecosystem?

Materials

a bare rock, a rock with lichen, a rock with moss, a rock with grass growing on it, soil plant (English Ivy), moist potting soil

Objectives

To develop an understanding of ecological succession
To appreciate the role of biotic and abiotic factors in modifying the environment
To be able to recognize ecosystems in different stages of succession
To be able to understand the dynamic nature of terrestrial ecosystems

Strategies

1. Before class, arrange the materials in the order in which they are listed above. Allow the class to look at the materials.

2. Discuss what is shown by the arrangement of the materials. Point out the apparent size differences between the specimens.

3. Review symbionts and the structure of a lichen. Point out that living lichens produce small amounts of weak acid. Elicit from the class what happens to the rock. Point out the destructive nature of acids on rock.

4. Pull some moss off the rock. Point out the very small "root system." Elicit from the class the type of surface that this plant would best grow on. Point out that moss only requires a thin layer of soil to live on.

5. Gently pull up some grass. Have class compare the root structure of grass and moss. Ask the class to describe the type of soil needed to support grass.

6. Use a sample of potting soil and have a student describe the potting soil. Define soil as a mixture of sand, clay, and dead plant and animal material.

7. Discuss what happens to the soil each year as plants and animals die. Elicit that soil is built up very slowly.

8. Display the English Ivy. Discuss the possible structure of its roots. Compare the roots to those of a tree.

What factors might change in our ecosystem that will allow different organisms to live there? Discuss changing soil depth as a factor.

9. Define succession as the process by which an area changes slowly and continually until it reaches a state of stability or maturity. Elicit that this is caused by the action of plants or animals in a community.

10. Elicit the roles of lichen, moss, and grass in the succession that occurs on bare rock.

11. Pioneer organisms (pioneer community) are the first organisms to grow on a surface. Lichens are an example of a pioneer organism. Elicit what happens to soil as pioneer organisms die.

12. Have students describe a forest community. Ask why there is very little or no grass on the forest floor. Elicit the lack of light under tall trees. What affect might this have?

13. Define climax community as a community where the conditions are very stable. These conditions are just right for the survival of dominant (major) types of plants. These plants will be replaced by members of the same species when they die.

14. Describe the following as an example of succession.

    Sand on a beach becomes covered with dead plants and animals washed ashore ⟶ pioneer grasses grow, trapping sand ⟶ soil formation occurs giving rise to ⟶ pine trees ⟶ oak forest ⟶ beech, maple forest ⟶ results in a climax community.

15. Review successional changes by discussing secondary succession in a vacant lot or an old building site. Define secondary succession as succession in an area that once supported a community (burnt forest).

Enrichment

1. Describe the plants growing in a crack in the sidewalk.

2. What kind of living things do you find in a vacant lot? Describe the soil or surface in the lot.

Lesson 39 Ecology - Lab Activity

Aim: What happens to a fallen tree?

Materials

variety of small logs collected from a woodland area, terrarium, field guide to protists, plants, invertebrates; magnifying lens, tape measure, dissecting tools

Preparation of Materials

Collected log samples should be wrapped in moist newspaper and secured in a protective plactic cover. Unwrap prior to classroom use.

Objectives

To appreciate the value of logs and the habitat they supply
To study the niches of organisms found on the log
To identify organisms through the use of a key
To describe characteristics of organisms
To observe the activities and interrelationships of organisms found on the log
To measure the physical characteristics of a log

Strategies

Note: If a log is not available, any suitable ecosystem (classroom terrarium) will suffice.

1. This lesson can be conducted as a demonstration or as a laboratory exercise. Depending upon this decision, a number of logs must be collected in advance of this lesson.

2. Discuss the role of a decaying log in an ecosystem in terms of: food source; place to live; place for reproduction and development; soil production; succession.

3. Distribute lab sheets to students. A group of students can work together on one log and should have free access to field guides for identification purposes.

4. At the end of the laboratory exercise, one or more logs should be placed in a terrarium for continued study throughout the year. The importance of returning the other logs to their original environment should be stressed to students.

STUDENT LABORATORY WORKSHEET

Lesson 39 What happens to a fallen tree?

Name ______________________ Date _______ Section ________

Introduction

During this laboratory activity, you will examine a log. Logs are really miniature habitats. They provide a source of food, living place, and location for reproduction and development for a variety of organisms. The activities of all these organisms will eventually destroy their habitat. The organisms are responsible for breaking down the log and returning it to the soil. From there, the components of the log will be recycled into other living organisms.

Materials

log sample, magnifying glass, dissecting tools, tape measure

Procedure

1. Carefully unwrap the log. Try not to permit any organisms to escape, or to remove any organisms attached to the log.

2. Determine some of the physical characteristics of the log. Use the tape measure and your senses. Record your observations on the data sheet.

3. Diversity Studies: Use your dissecting tools to carefully remove sections of the bark. Examine the interior of the log. If time permits, use field guides to help you identify organisms you do not recognize. Record your observations on the data sheet.

   Under the column heading Activities, include where the organisms is found, its possible interactions with other organisms, and its food source.

4. When you have completed your observations, clean and return the materials. If your log has been selected for further study, place it in the terrarium provided by your teacher.

Post Lab Questions

1. Describe the succession that took place in the log from the time that it was on the tree until you examined it.
2. Describe as many food chains as you can for the organisms you observed on your log.
3. What niche does each organisms in your diversity list occupy?

STUDENT DATA SHEET

Lesson 39 What happens to a fallen tree?

Name ______________________ Date __________ Section ________

I. Log Description

Length of Log	______ cm
Circumference of Log	______ cm
Color of Bark (circle one)	dark brown, brown, gray
Bark Texture (circle one)	no bark, smooth, rough
Moisture Content (circle one)	dry, damp, moist, wet
Degree of Decomposition (circle one)	solid, soft, crumbles

II. Diversity Studies

Organism number	Description	Name	Activities	Number observed
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Lesson 40 Soil Characteristics - Lab Activity

Aim: How can soil be analyzed?

Materials

screen sieve kit
balance
test tube
red litmus paper
plastic spoon
water
4 large paper cups
soil sample
blue litmus paper
hydrion paper
medicine dropper

Objectives

To be able to analyze soil texture
To be able to determine soil pH
To be able to recognize the importance of soil chemistry

Strategies

1. Divide students into small groups. You may want to have each group member perform a different activity.
2. For variety, a variety of soil types may be used.
3. Some tests included in the soil test kit may be demonstrated.
4. Distribute laboratory worksheets and student data sheets.
5. Circulate among the students as they work.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 40 How can soil be analyzed?

Name ______________________________ Date __________ Section ________

Introduction

Soil is a mixture of many different materials. It is made up of the remains of plants and animals, and small pieces of rock material that are broken down by the action of weather, water, and living things. When soil is analyzed chemically, it is found to contain many substances. Among these substances are silica (sand), iron, aluminum, calcium, phosphorus, potassium, and nitrates. These substances are needed for proper plant growth. In addition, soil also contains salts, acids, water, and organic material.

You will be performing several activities designed to determine soil properties that are important for plant growth. The properties you will be testing are soil texture and soil pH.

Texture refers to the size of the particles found in soil. Soil particles may be made of clay, silt, sand, and gravel. Clay is the smallest of these particles, the next largest particles are silt, sand, and gravel.

Soil pH refers to how acid or basic soil is. Acid soils are found in forests. Leaves that fall and decay help form acids in the soil. Basic soils are found in the desert. Different plants live in soils with a specific pH.

I. Soil Texture

Materials

screen sieve kit
balance
4 large paper cups
soil sample

Procedure

1. Determine the total weight of your soil. Do not forget to subtract the weight of the container used to hold the soil. Enter the weight on the student data sheet.
2. Use the sieve with the largest mesh opening. Place this sieve (mesh down) into a paper cup. Carefully pour your soil into the sieve. Shake the sieve until no more soil particles fall through. Examine the material in the sieve. Which soil particles are in the sieve (clay, silt, sand, or gravel)? Enter this data on the student data sheet.
3. Place the material in the sieve into a cup. Label it No. 1. Set it aside.

4. Use the sieve with the next largest mesh opening. Repeat the procedure just followed. Enter the soil particle size on the data sheet. Continue separating the soil samples until you have four cups, each containing different-sized soil particles. Number each cup and enter the particle size on the data sheet.

5. Weigh each of the soil samples. Do not forget to subtract the weight of the containers. Enter the weight on the data sheet.

6. Use the following formula to calculate the percent by weight for each soil sample.

$$\frac{\text{Sample wt.}}{\text{Total wt.}} \times 100$$

Enter your results on the student data sheet.

7. Mix a small amount of each sample with some water. Observe the following:
    a) clay sticks together
    b) sand crumples apart, feels gritty
    c) silt is in between clay and sand and feels like talcum powder

II. Soil pH

Materials

test tube	red litmus paper
blue litmus paper	hydrion paper
plastic spoon	medicine dropper
water	

Procedure

1. Place about ½ spoonful of soil into a test tube.

2. Fill the test tube 3/4-full with water. Mix well and allow the soil to settle to the bottom.

3. Use a medicine dropper. Place a drop of the water from the test tube on each of the pH test papers.

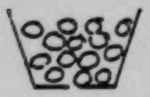
4. What color changes did you observe? Enter these on the data sheet.

5. What is the pH of your soil sample? Enter this on the data sheet.

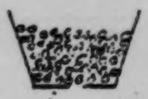
Observations and Conclusions

1. My sample had the highest percentage of (circle 1)
   a) gravel b) sand c) silt d) clay
2. My sample had the lowest percentage of (circle 1)
   a) gravel b) sand c) clay d) silt

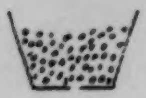
Use the following illustration to help you answer the questions below.



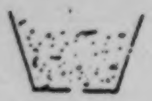
A
gravel



B
Sand



C
silt



D
clay

3. If water were poured into each of the cups, which material would allow the water to flow most freely to the bottom? ______________
4. Which material would allow the least free flow? __________

STUDENT DATA SHEET

Lesson 40 How can soil be analyzed?

Name ______________________ Date _______ Section __________

I. Soil Texture

Total soil weight ________ grams.

Sample No.	Particle Size	Weight (g)	% Wt.
1			
2			
3			
4			

II. Soil pH

Test paper	Result
red litmus	
blue litmus	
hydrion	

pH (from hydrion paper) __________

Lesson 41 Growing Soil Microorganisms- Lab Activity

Aim: How can a culture of soil microorganisms be prepared?

Materials

prepared nutrient agar petri dishes, spatula, soil sample, test tube, water, balance, inoculating loop, bunsen burner, safety matches, incubator, stereoscopic microscopic (if available), autoclave

Preparation of Materials

Nutrient agar may be prepared by carefully following the directions on the jar label.

Objectives

To learn skills necessary to culture bacteria
To be able to detect the presence of bacteria in soil

Strategies

1. Caution students about the safety factors involved in the use and study of bacteria. Emphasize that safety procedures must be strictly adhered to.

2. Before students actually begin the activity, demonstrate how to sterilize the inoculating loop. Also demonstrate the proper technique for streaking a culture plate. (Raise only one edge of the cover to permit access to the agar surface).

3. Caution students not to break the surface of the agar. The inoculating loop should be used like a fine paint brush (gently and held at an angle).

4. Before petri dishes are stored for incubation, they should be labelled and taped closed. After incubation, petri dishes should not be opened.

5. At the end of the activity, petri dishes should be autoclaved according to specifications.

6. Distribute worksheets and materials. Circulate among students as they perform the activities.

STUDENT LABORATORY WORKSHEET

Lesson 41 How can a culture of soil microorganisms be prepared?

Name ______________________ Date ___________ Section _______

Introduction

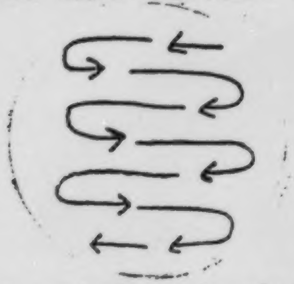
Many organisms make their homes in the soil. Among the most important of these are soil bacteria. Soil bacteria play many useful and important roles in the formation and maintainance of the soil ecosystem. Many soil bacteria are bacteria of decay which get their food by breaking down the bodies of dead plants and animals. Organisms, such as bacteria, that live on dead and decaying matter are known as saprophytes. During their food-getting, soil bacteria produce many chemicals that are needed by plants for growth. In this laboratory exercise a special food called nutrient agar will be supplied by your teacher. You will be able to grow bacteria extracted from a soil sample on the nutrient agar.

Materials

prepared nutrient agar petri dishes, spatula, soil sample, test tube, water, balance, inoculating loop, bunsen burner, safety matches, incubator, stereoscopic microscopic (if available)

Procedure

1. Place 5 ml of water into a test tube. Add .5 g of soil.
2. Mix well and allow the soil to settle to the bottom of the test tube.
3. Sterilize (heat until red) an inoculating loop in the flame of your burner. Allow it to cool.
4. Transfer one loopful of water from the test tube to the prepared petri dish. Gently rub the inoculating loop across the agar surface in an "S" pattern as illustrated.



STREAK PLATE

Label the petri dish with your name and section.

5. Cover the petri dish and place it in a 24°C incubator or leave at room temperature for 48 hours.

6. After 48 hours, observe the petri dish under the stereoscopic microscopic. Do not open the dish. Count the number of colonies or patches of bacteria you observe on the plate.

7. Describe the differences you can observe between the individual colonies. Look for such differences as luster, color, texture, and size.

Observations and Conclusions

1. Which soil sample did you use?
2. How many colonies of bacteria were found after 48 hours?
3. Why did you sterilize the loops before you used them?
4. What is the purpose of the nutrient agar?
5. Why did we have to wait 48 hours to see the microorganisms?
6. What is the role of soil microorganisms?
7. What evidence is there that more than one type of bacteria are present?

Lesson 42 Biomes: Tundra and Desert

Aim: What are the least populated areas on earth?

Materials

world map or globe, audiovisual materials or pictures illustrating land biomes, terraria showing desert conditions, cacti, resurrection plant, succulent plants, lichens

Objectives

To recognize that there are many areas of the earth with similar conditions- biomes
To understand the factors that determine a biome
To determine the niches of organisms found in each biome
To evaluate the special adaptations that organisms have made to live in a biome and understand why they are useful

Strategies

1. Discuss the conditoins under which an area might be referred to as a desert. Elicit the fact that a lack of water, rather than the presence of high temperatures produces a desert. Explain that there are deserts which are very hot, as in Death Valley; and deserts such as those in the northern United States and Canada, which are cold. Indicate the location of deserts on the world map or globe.

2. Guide students to an understanding that both hot and cold deserts of the United States have similar conditions; i.e., little rainfall and similar climax plants (sagebrush and cactus). Sets of similar conditions often occur over large regions of the earth. These regions are known as biomes. Biomes do not have sharp borders, but gradually blend into the next region.

3. Explain that each biome has a certain number of available niches. Each has a dominant type of producer, and primary, secondary, and tertiary consumers.

4. Conduct a general class discussion on desert biomes. Order the discussion using the following as a guide.

   Desert Biomes
   a) Location- can be found all over the world at different latitudes (review latitude- the distance north or south of the equator).
   b) Limiting Factors- little rainfall (less than 25 cm), scattered unevenly during the year.

c) Community- harsh environment; few plants but large numbers of animals, many of which are nocturnal (become active at night).

Producers- Cactus stores water in stems; waxy stems; needle-like leaves. Some shrub-like plants have roots that extend downward for many meters. Others can drop leaves during dry spells. Both of these adaptations are designed to retard water loss. Some plants are short lived. They grow, bloom, and produce seeds in a few weeks when the moisture is good for growth. Display Resurrection plant if available.

Consumers- Insects and reptiles have thick outer coverings to prevent water loss. Mammals live in burrows during the day and emerge at night. Elicit examples of animals: coyotes, foxes, small cats, skunks, badgers, snakes, hawks, owls, vultures, kangaroo rats, jack rabbits, lizards, tarantulas, and road runners. Discuss the interactions of these organisms.

5. Challenge students to describe other areas of the earth. Elicit that there are cold, treeless regions which have a permanently frozen subsoil and support only low-growing vegetation. Define such a region as a tundra.

6. Conduct a general class discussion on the tundra. Order the discussion using the following as a guide.

Tundras

a) Location- along northern border of North America, Europe and Asia (locate on map).

b) Limiting Factors- very low temperatures. Ground permanently frozen- permafrost- preventing groundwater from seeping through ground. Only upper few centimeters thaw during short summer.

c) Community- Why is this such a harsh environment? What types of plants would you expect to find in such thin soil?

Producers- Dwarf plants, lichens, mosses and grasses.

Consumers- Ground squirrels, lemmings, caribou, arctic foxes, snowy owls, wolves, and people. Elicit differences between winter and summer populations. Summer-water birds, plovers.

d) Animals that are found in a tundra need special adaptations for winter. Elicit some of these from students:
migration- birds
hibernation- ground squirrels
white coats- snowy owls, arctic foxes
move southward to edge of tundra- caribou

7. Discuss the interactions of organisms. Assist students in constructing food chains similar to the following.

   moss → caribou → arctic wolf

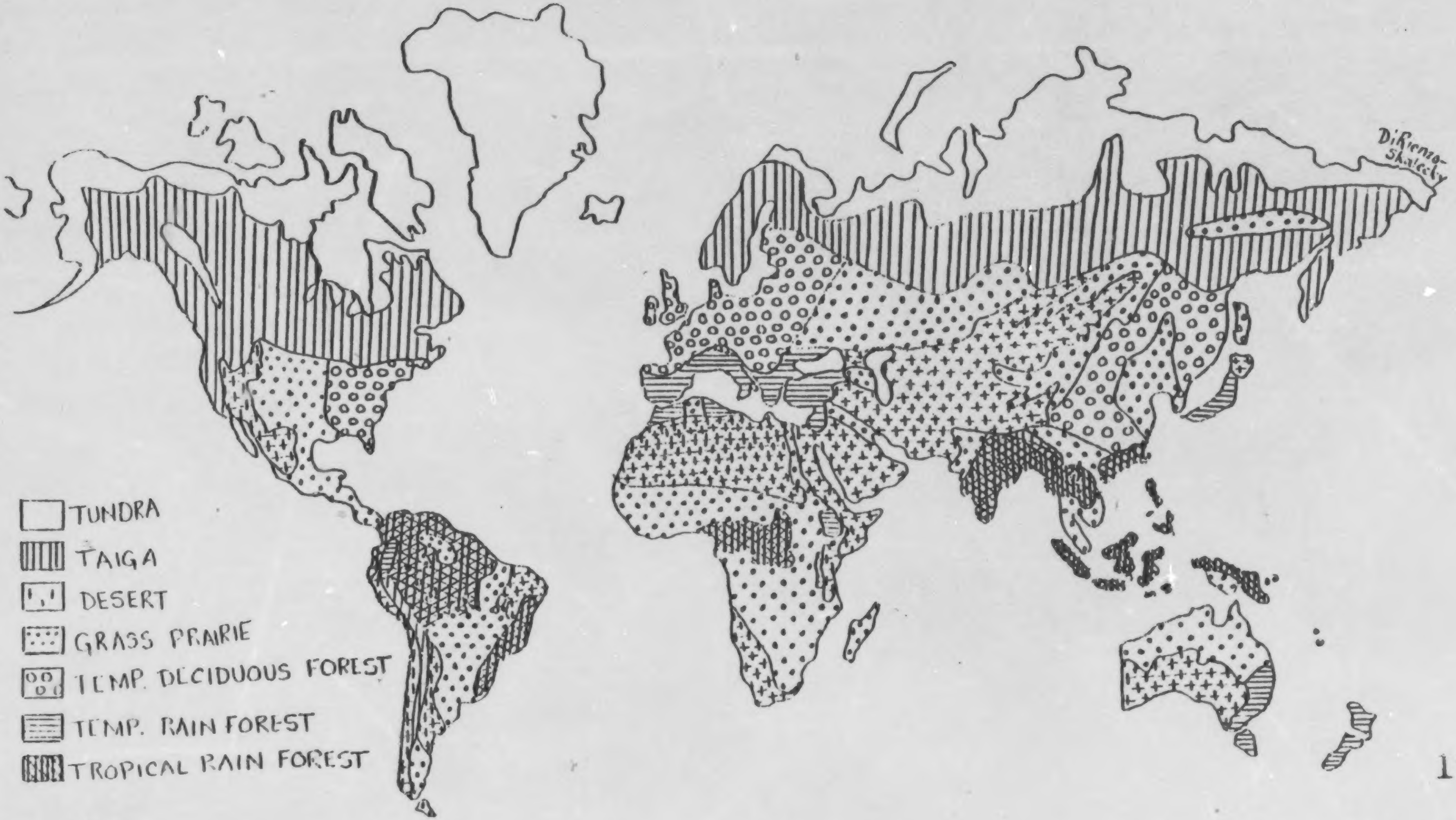
8. Distribute chart Biomes of the World. Provide references and assist students in completing the chart for the desert and tundra.

Enrichment

Discuss with students the objections of environmentalists about the Alaska pipeline. What effects would warm petroleum flowing through a pipe have on the permafrost? How might an above-ground pipeline affect the migrational activities of caribou?

What would be the effects of an underground pipeline on the permafrost?

BIOMES OF THE WORLD


DiRienzo-Skalecky
☐ TUNDRA
▥ TAIGA
DESERT
GRASS PRAIRIE
TEMP. DECIDUOUS FOREST
▤ TEMP. RAIN FOREST
▦ TROPICAL RAIN FOREST

BIOMES OF THE WORLD

BIOME	YEARLY RAINFALL	CLIMAX PLANTS	SMALL HERBIVORES	LARGE HERBIVORES
DESERT				
TUNDRA				
TIAGA				
TEMPERATE DECIDUOUS FOREST				
GRASSLANDS				
TROPICAL RAIN FOREST				

Lesson 43 Biomes: Taiga and Temperate Deciduous Forest

Aim: What kinds of forest biomes are found in the United States?

Materials

world map or globe, audiovisual aids or pictures of land biomes, pine and other evergreen cones

Objectives

To understand the factors that determine a biome
To determine the niches or organisms found in each biome
To evaluate the special adaptations that organisms have made to live in a biome and understand why they are useful

Strategies

1. Have the students recall that biomes do not have sharp borders, but gradually blend into the next region. Challenge the students to explain what type of biome would be found just south of the tundra. Elicit that this is the Taiga or Coniferous Forest Biome.

2. Conduct a general class discussion on the Taiga or Coniferous Forest Biome. Order the discussion using the following as a guide.

   Taiga or Coniferous Forest Biome
   a) Location- Broad band just south of the Arctic tundra across North America, Asia and Europe (locate on map).
   b) Limiting Factors- Short summer, long, cold winter, but not as harsh as tundra. More rainfall than tundra (40 to 100 cm per year), and a longer growing season. Poor soil.
   c) Community- Conifers; large number of animals.

   Producers- evergreen trees (conifers): spruce, pine, fir, hemlock.

   Consumers- squirrels, birds, insects, moose, snowshoe hare, deer, elk, caribou (during winter), hunting birds, wolves, pumas, black bears, foxes, and weasels.

3. Challenge students to compare the diversity of organisms in the taiga with that of the tundra.

4. Adaptations
   How are the trees of the taiga adapted for long, dry, winters? Elicit that plants have needle-like leaves to prevent against water loss. Ask what factors contribute to the greater diversity in the taiga.

5. Discuss the interactions of organisms. Assist students in constructing food chains similar to the following.

   grass ⟶ snowshoe hare ⟶ lynx

6. Develop a class discussion which compares and contrasts the organisms (plant and animal) of the taiga with those of the forests of New York and New Jersey. Elicit those climatic conditions which might account for differences.

7. Conduct a general class discussion on the Temperate Deciduous Forest. Order the discussion using the following as a guide.

   Temperate Deciduous Forest
   a) Location- Beneath taiga in a band (temperate zone) across North America, Asia, and Europe. Also South America (locate on map).
   b) Limiting Factors- Abundant rainfall (80 to 120 cm), evenly spaced throughout the year; cold winters, warm summers and distinctive spring and fall season.
   c) Community- Climax vegetation; large variety of animals.

      Producers- climax vegetation is an assortment of broad-leaved trees. Most forests are a mix of two major trees; e.g., beech-maple (northern) and oak-hickory (southern and western).

      Consumers- great variety. Elicit from students the many examples: birds, insects, and other invertebrates, squirrels, racoons, rabbits, foxes, bears, deer, weasels, and bobcats.

   d) Adaptations- Challenge students to explain how trees of the temperate deciduous forest are adapted for cold winters. Elicit that the trees are deciduous; they lose their leaves in the winter. This helps prevent water loss when the ground is frozen.

8. Discuss the interactions of organisms. Assist students in constructing food chains similar to the following.

   blueberry bush ⟶ starling ⟶ hawk

9. Elicit a comparison between the taiga and temperate deciduous forest. Establish that the seasonal changes that occur in deciduous forests are more severe than seasonal changes that occur in a taiga. In the deciduous forest, summer is warm, and the forest is shady and protected from winds. There is abundant vegetation for food. Winters are cold and harsh. In the taiga, there is a more constant climate.

10. Encourage students to complete the chart for taiga and temperate deciduous forest.

Lesson 44 Biomes: Grassland and Tropical Rain Forest

Aim: What other major biomes are found on the earth?

Materials

world map or globe, audiovisual materials or pictures showing land biomes

Objectives

To understand the factors that determine a biome
To determine the niches of organisms found in each biome
To evaluate the special adaptations that organisms have made to live in a biome and understand why they are useful

Strategies

1. Pose the following question: If you travel from New York to Omaha, Nebraska, would you be able to notice any changes in biomes? Elicit that Omaha is located in the Great Plains; a vast Grassland biome located in the center of the country. Have students compare the amount of rainfall that falls in coastal areas with the amount that falls in the central areas. Elicit that the further an area is from the coast, the less rainfall it receives.

2. Conduct a general class discussion using the following as a guide.

   Grassland
   a) Location- usually the interiors of continents:
   North America- Great Plains, Asia- Steppes
   South America- Pampas, Africa- Savannahs
   (Locate these areas on the map).

   b) Limiting Factors- Moderate temperatures as in the deciduous forests. Challenge students to think of reasons why forests do not grow here. Elicit that there is too little rainfall to permit growth of trees (about 25 to 80 cm per year). Relatively shallow depth of soil.

   c) Organisms- Elicit from students.
   Producers- Variety of grasses.
   Consumers- Insects and other invertebrates, gophers, prairie dogs, deer, mice, bison, prong-horn antelops, coyotes, bobcats, hawks, owls, and snakes.

   d) Adaptations- Elicit how branching roots of plants are a special adaptation for life in the grasslands. Establish that deep roots draw water for plants during occasional droughts. They also form a dense network which holds soil in place during winter.

3. Elicit the advantages that animals living in herds have for survival.

4. Discuss the interactions of organisms. Assist students in constructing food chains similar to the following.

grass → prairie dog → snake → hawk

5. In Grassland biomes, there are large herbivores. Challenge students to suggest the names of herbivores found on the following continents.
   Europe- horses
   North America- bison and prong-horn antelope
   Australia- kangaroos
   Africa- zebras

   Organisms that occupy the same niche, but in biomes located in different places are known as ecological equivalents.

6. Challenge students to suggest which terrestrial ecosystem receives the greatest amount of rainfall.

7. Conduct a general class discussion on the Tropical Rain Forest.

   Tropical Rain Forest
   a) Location- Equatorial jungles of South America, central America, central Africa, and southeast Asia. (Locate on map).

   b) Limiting Factors- Heavy rainfall during most of the year; little temperature variation from winter to summer. Elicit why these would be limiting factors.

   c) Community- Has the greatest variety of life and the most stable, complex ecosystems.
   Producers- Broad-leaved evergreens having shallow roots; climbing vines. Produces dense shade, so little light reaches the ground.
   Consumers- The large variety of amphibians, reptiles, birds and mammals makes it difficult to list dominant types.

   d) Adaptations- Some animals are brightly colored, some have remarkable camouflage (cf. "Adaptations")

   What is the advantage of broad leaves to a jungle tree?

8. Discuss adaptations, and interactions of organisms in this biome.

9. Allow students to complete chart on biomes by filling in remaining boxes across from Tropical Rain Forest and Grasslands.

Enrichment

1. Discuss similarities in the care of typical houseplants with the conditions in a tropical rain forest (moisture, indirect sunlight, temperature).

2. Discuss the sequence of biome changes due to an increase in altitude on high mountains.

Lesson 45 Mini-Ecosystems- Lab Activity

Aim: How can we create a miniature ecosystem?

Materials

large, clear glass jar with top, gravel, activated charcoal, top soil, sand, plant cuttings or small plants, plastic spoons, paper towel

Objectives

To devise a model miniature ecosystem
To prepare a suitable container for living organisms
To plant and arrange producers in the ecosystem
To observe the ecosystem for several weeks

Strategies

1. Students should be instructed to bring in a large, wide-mouth, clear glass container (jar) with a cover. A large cellophane bag may also be used. Suitable plants may be collected by the teacher, or obtained from a local greenhouse. This lab can be adapted for the construction of aquaria.
2. Distribute student laboratory worksheets. Review the procedures.
3. Encourage students to work on their individual terraria and take them home for observation.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 45 How can we create a miniature ecosystem?

Name ______________________ Date __________ Section _______

Introduction

An ecosystem is usually a very large area in nature, and so it is very difficult to study all the factors found there. What you will try to do in today's lab will be to reproduce many of the natural conditions in an ecosystem, but on a much smaller scale. If you have a fish tank aquarium or an enclosed terrarium you already have a miniature ecosystem. If your plants or animals have survived for a while, this is a good indication that a proper balance of abiotic and biotic components exists.

You will try to create mini-ecosystems in jars and containers that are relatively small. These can be taken home for observation.

Materials

large, clear glass jar with top, gravel, activated charcoal, top soil, sand, plant cuttings cr small plants, plastic spoons, paper towel

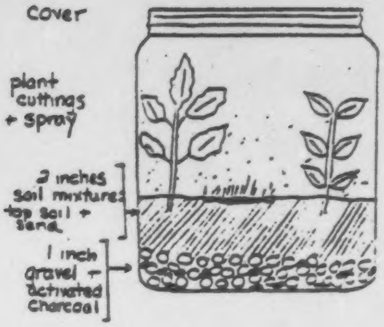
Procedure

1. Cover the bottom of the container with at least 3 cm of gravel (for drainage) in which you have mixed pieces of activated charcoal. The charcoal sweetens the soil (changes the pH) and helps to prevent harmful bacteria from growing.

2. Add about 5 cm of soil mixture (top soil and sand) to the jar. Be careful not to disturb the bottom layer.

3. Very carefully add cuttings from large plants or add several small plants. Using a pencil, gently push the stem or roots into the soil. Be as artistic as possible.

4. Spray the plants with water and cover the terrarium. For the first few weeks you may have to adjust the humidity in your mini-ecosystem. A fine beading of moisture on the walls of the container indicates the right amount of water. A dense fog means too much; no moisture in sight means not enough.


cover
plant cuttings + spray
2 inches soil mixture: top soil + sand
1 inch gravel + activated charcoal

Observations

List each of the items (components) in your ecosystem. Complete the following chart.

Component	Biotic or Abiotic	Producer, consumer, or decomposer?	Why was it added?

Post Lab Questions

1. Construct a food chain that is present in your mini-ecosystem.
2. Use a diagram to show how materials (gas, water) are cycled in your ecosystem.
3. Why will the mini-ecosystem be able to survive even after the jar is closed?

UNIT V

POPULATION

The ability of an ecosystem to sustain itself is directly related to the reproduction potential of its inhabitants. In Unit V, reproduction and development cycles are studied in several representative organisms. Through graphing and analysis, the characteristics of population growth are examined for both human and wildlife populations. Students are lead to the understanding that carrying capacity determines the overall potential for growth within an ecosystem. From this understanding emerges the need for wildlife management and conservation.

The unchecked growth of human populations introduces potential problems, e.g., food shortages, overcrowding, and deterioration of the environment. Examination of these issues leads to discussions that point to a need for practical solutions.

Lesson 46 Reproduction

Aim: Where do new organisms come from?

Materials

3 small baby food jars, 3 small pieces of meat, cellophane, gauze, rubber bands, cell model or chart

Objectives

To discuss the theory of spontaneous generation
To understand the need for reproduction for the continuity of a species
To understand that all living things are made of cells that contain the mechanism for reproduction
To understand the importance of the chromosome in reproduction
To examine the process of mitosis as a means of cellular reproduction

Strategies

1. Discuss the theory of spontaneous generation. Explain that at one time, it was believed that flies and other living things came from decaying meat. Challenge the students to design an experiment to help disprove this concept.

2. Outline the experiments performed by F. Redi. Demonstrate the approximate technique employed by Redi to disprove the theory of spontaneous generation. Set up three jars, each with a small piece of meat in it. Describe what occurred.

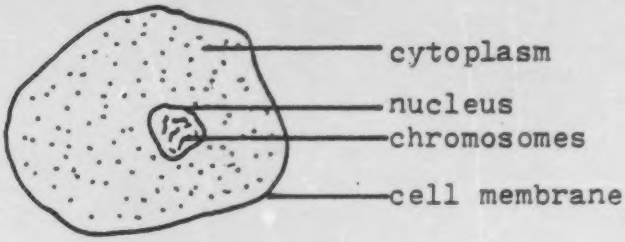
   Jar 1: open; flies seen in jar, jar contained maggots after several days.
   Jar 2: covered with gauze; flies observed near top of jar, contained maggots after several days.
   Jar 3: covered with cellophane (air tight); no flies observed near jar; no maggots observed after several days.

3. Elicit the conclusions reached by Redi based upon this experiment. Challenge students to explain whether or not this was a controlled experiment.

4. Develop the concept that living things are able to produce more of their own kind. Define this as reproduction.

5. Challenge students to explain why living things must reproduce. Elicit that reproduction is not necessary for the survival of the individual, but it is necessary for the survival of the species.

6. Briefly review the concept of the cell as the smallest unit of life. Explain that the nucleus is the control center of the cell. It contains chromosomes (DNA) which carry the information necessary to produce a new cell or organism. Establish the fact that the nucleus duplicates itself by splitting and that this nuclear division is referred to as mitosis. Establish also that mitosis is followed by the splitting or dividing of the cell to form two new cells.



7. Discuss the importance of mitosis for the growth of an organism and the difference between growth and reproduction.

8. Establish that there are two major types of reproduction; asexual and sexual. Explain that in asexual reproduction, an individual cell divides to produce two new cells. In asexual reproduction, there is only one parent. In sexual reproduction, two cells unite or join to produce a new cell. In sexual reproduction, two parent cells are required to form a new cell.

Enrichment

Research the work of L. Pasteur and L. Spallanzani. How did the work of these scientists contradict the theory of spontaneous generation?

Lesson 47 Asexual Reproduction

Aim: What are some forms of asexual reproduction?

Materials

wall charts or prepared slides illustrating forms of asexual reproduction; microprojector (if available)

Objectives

To define reproduction
To examine forms of asexual reproduction including fission, budding, spore formation, regeneration, and vegetative propagation
To discuss the advantages and disadvantages of asexual reproduction

Strategies

1. Have students recall their learnings from the previous lesson. Briefly review the basic differences between asexual and sexual reproduction.

2. Establish that in asexual reproduction, a set of chromosomes from only one parent is passed on to the next generation (offspring). Elicit that the offspring possess traits which are identical to those of the parent.

3. Project and discuss slides which illustrate the forms of asexual reproduction. Discuss such forms of asexual reproduction as:
   a) Binary fission - division forming two organisms of equal size: e.g., ameba, paramecium, bacteria.
   b) Budding - division forming two organisms of unequal size: e.g., yeast, hydra.
   c) Spore formation - similar to fission except that many small cells of equal size are formed. Spore is usually covered by a spore case: e.g., bread mold.
   d) Regeneration - growth of lost parts of an animal: e.g., starfish, lobster, planaria.
   e) Vegetative Propagation - growth of an entire plant from a portion of the stem, leaf, or root.
      1) tubers - underground stem: e.g., potato
      2) bulbs - underground stem and leaves: e.g., onion, tulip.
      3) stem cuttings: e.g., houseplants
      4) grafting - splicing of closely-related plants: e.g., seedless oranges
      5) rhizomes - underground stems: e.g., grasses
      6) runners - above-ground stems: e.g., spider plants

4. Elicit the advantages of asexual reproduction.
   a) All of the offspring has the same characteristics as the parent. Explain why.
   b) Offspring are produced more rapidly than by sexual reproduction.

5. Elicit the disadvantages of asexual reproduction.
   a) Lack of diversity within an individual species.
   b) Offspring are less likely to be more vigorous than parent.

ADDITIONAL TEACHER NOTES

Lesson 48 Reproduction and Growth in Microorganisms - Lab Activity

Aim: How do microscopic organisms reproduce?

Materials

small baby food jar
pond water (if available)
cover slip
medicine dropper
dried plant material
slide
microscope
paper towel

Objectives

To examine reproducing microorganisms under the microscope
To note changes in the number of organisms
To explain the conditions necessary for reproduction to take place

Strategies

1. Allow students to prepare their own hay infusion by putting bits of plant material into bottles of water.
   Students may inoculate each bottle with a drop of pond water.
2. Review rules for the proper use of the microscope and for the preparation of slides.
3. Distribute worksheets.
4. Encourage students to observe several drops of water.
5. Collect hay infusion and permit students to observe again after several days.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 48 How do microscopic organisms reproduce?

Name____Date_________Section___________

Introduction

Many strange and exciting organisms inhabit pond water. In a drop of pond water, you may see organisms you have never seen before. You will create your own miniature pond by making a hay infusion. You will then examine the water and try to locate and identify several organisms. In several days, you may notice a change in the number and kind of microscopic life in your hay infusion. Try to identify some of the activities performed by the organisms. You may even be able to see some of these organisms during a stage of reproduction.

Materials

small baby food jar
pond water (if available)
cover slip
medicine dropper
dried plant material
slide
microscope
paper towel
distilled water

Procedure

1. Fill the jar about three quarters full with distilled water. Place several pieces of dried plant material into the water. If pond water is available, add a few drops to the jar.

2. Use the hay infusion - pond water mixture to prepare a slide. Observe under the microscope. Locate and draw several of the organisms you see. Record the color, number, and activity of the organisms you observe in Table 1 on the data sheet.

3. Enter the total number of organisms observed.

4. After you have completed your observations and data entry, clean all equipment and return it. Your teacher will collect the hay infusion so that you may observe it again after several days.

5. After several days, repeat Procedure 2 and 3 and enter your observations in Table 2 on the data sheet. Clean all equipment and return it.

Post Lab Questions

1. How might green and non-green organisms in your culture be dependent upon one another

2. What difference was there in the number of organisms you observed during the observation? How can you explain this?

3. What type of reproduction do most of these organisms have? give examples.

4. There may be organisms that you saw only on the second day. Where did these come from?

STUDENT DATA SHEET

Lesson 48 How do microscopic organisms reproduce?

Name____Date______Section____________

Table 1 First Day Observations - Date________

Organism	Color	Number	Activity

Total number of organisms observed____________.

Table 2 Second Day Observations - Date______

Organism	Color	Number	Activity

Total number of organisms observed____________.

Lesson 48 How do microscopic organisms reproduce?

Name______________________________Date_____________________ Section__________

First Observations Drawings-Date_____________

Second Observations Drawings-Date_________________

Lesson 49 Sexual Reproduction

Aim: How do organisms reproduce with two parents?

Materials

chart of human reproductive system, illustration of flower (for distribution), flower

Objectives

To understand the need for the production of gametes
To study the reproductive system of a typical plant or animal
To understand why the process of fertilization results in new organisms
To examine the development of organisms from fertilized eggs
To list the requirements necessary for external and internal fertilization and development

Strategies

1. Review the basic differences between asexual and sexual reproduction.

2. Explain that the two cells that unite during sexual reproduction are known as gametes. Develop the understanding that these cells are highly specialized in that they possess only half the normal number of chromosomes. Challenge students to explain the significance of this.

3. Elicit that sperm cells are male gametes produced in the testes.

4. Elicit that egg cells are female gametes produced in the ovaries.

5. Using a wall chart, locate and identify the organs of the male reproductive system. Explain the function of the testes, sperm tube, urethra, and penis.

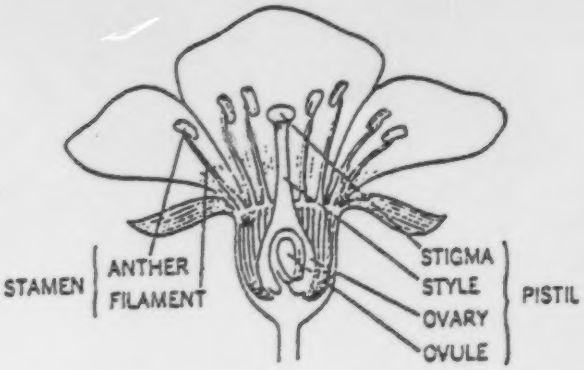
6. Locate and identify the organs of the female reproductive system. Explain the function of the ovaries, oviducts, uterus, vagina, and urethra.

7. Discuss fertilization. Explain that during fertilization, the sperm nucleus and the egg nucleus unite to produce a new cell. This new cell will divide repeatedly and eventually form an embryo (organism in its early stages of development). Elicit that the embryo will eventually develop and form a complete organism with traits from each of the parents.

8. Develop the concept that although fertilization is the same for animals that reproduce sexually, where it occurs may be different. For example, external fertilization occurs outside the body of the female; usually in some kind of watery environment: e.g., fish and amphibians. Internal fertilization occurs inside the body of the female: e.g., reptiles, birds, and mammals.

9. Elicit that development of the embryo depends upon where the fertilization takes place. Thus, development is either external or internal. External development requires a watery environment. Fish and amphibian embryos have an aquatic environment. Reptile and bird embryos possess a shell which helps maintain a watery environment. Internal development takes place in the body of the female. Among the mammals, a special organ, the uterus, maintains the environment for the embryo.

10. Distribute the illustration showing the reproductive parts of a plant. Elicit that plants also reproduce sexually. Pollen grains are the male gametes. During pollination, pollen is transferred from the male reproductive organ (stamen), to the female reproductive organ (pistil). Fertilization occurs deep within the pistil. The fertilized egg forms an embryo which is found inside a seed.



Lesson 50 Reproduction in Insects - Lab Activity

Aim: How do fruit flies reproduce and develop?

Materials

fruit fly cultures, chart illustrating life cycle of fruit fly, hand lens

Objectives

To examine a culture of reproducing fruit flies
To observe the stages in the life cycle of a fruit fly

Strategies

1. Use a reproducing culture of fruit flies for students to study.
2. Remind students to keep the culture bottles closed while making observations.
3. This lesson may be modified and/or adapted for use with guppies, frogs, mice, chickens, or other suitable laboratory animals.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 50 How do fruit flies reproduce and develop?

Name______________________________Date___________Section__________________

Introduction

In addition to being useful for studying reproduction and development, the fruit fly has been used for many years in the study of genetics, the science of heredity.

In the laboratory activity, you will learn about the complete changes in physical structure, or metamorphosis, that a fruit fly undergoes in its growth from egg to adult. Fruit flies reproduce rapidly. One female may lay as many as 500 eggs in 10 days.

Materials

fruit fly culture, hand lens

Procedure

1. The time taken for metamorphosis from egg to adult is about two weeks. Your culture should contain organisms in various stages so you can complete your observations today.

2. Look for an egg. This is a very small, white, oval form with two fibers extending from the sides. The fibers are used for suspension. The fruit fly does not remain in the egg for very long. The day the egg is laid, it will hatch into the next stage. Draw a picture of a fruit fly egg in the space provided on the data sheet. (The eggs can be found in the culture food). Also record the color.

3. The larva is the next stage in the development of the fruit fly. Larva have black mouth parts that are constantly moving. They can be found forming tunnels in the food, or on the sides of the bottle. The fruit fly will molt, or shed its outside covering, three times during this stage. Locate a larva and draw a picture of it in the space provided on the data sheet.

4. In the pupa stage, the metamorphosis (or change) into a fly occurs. The outer covering of the larva forms a yellow-brown pupa case. In this stage, the organisms are stationary; they do not move. You may be able to see the folded wings and eyes of the fruit fly as they form. Locate a pupa and draw a picture in the space provided on the data sheet. Record the color.

5. After metamorphosis is completed, the adult forces its way out of the pupa case. At first the fly is light in color and its wings are folded. As fruit flies mature, they darken in color. The males are smaller and have darkened, rounded bottoms. The females are a little larger, lighter, and more pointed at the bottom. The female is capable of

laying eggs two days after it emerges. Locate an adult, and draw it in the space provided. Determine the sex and record it.

6. How many legs does the adult fruit fly have? _______

7. How many wings does it have? _______

Post Lab Questions

1. Name and describe each of the stages in the life cycle of a fruit fly.

2. Name four insects that undergo a metamorphosis similar to that of the fruit fly.

3. To which phylum and class does the fruit fly belong?

4. What kind of reproduction do fruit flies illustrate?

5. What type of fertilization do fruit flies have?

6. What type of development do fruit flies have?

STUDENT DATA SHEET

Lesson 50 How do fruit flies reproduce and develop?

Name__________________________Date__________Section__________________

Egg

Egg color __________

Larva

Larva color __________

Pupa

Pupa color __________

Adult

Sex __________

Lesson 51 Carrying Capacity - Wildlife Populations

Aim: How does the environment affect wildlife populations?

Objectives

To demonstrate and explain some of the techniques used to study wildlife populations
To analyze the requirements for a stable natural population - limiting factors
To examine why the limiting factors determine the carrying capacity of an area
To understand the role of predators in maintaining the balance of nature
To illustrate that human interference in natural food chains usually upsets the balance of nature - as explained by the story of the Kaibab deer

Strategies

1. Discuss some of the factors that are important to the ecology of populations. Consider such factors as:
   a) Distribution of organisms - random, ordered, clumped.
   b) Growth of population.
   c) Effect on other populations - predators, competition.

2. Discuss methods used to study wild plant and animal populations. Include such methods as:
   a) quadrat technique - sample technique
   b) transect - environment vs. diversity
   c) seining - to measure population diversity
   d) hunting kills
   e) visual counts of winter herds
   f) capture - recapture methods

3. Ask students to identify factors that might affect the survival of organisms in the wild. Elicit such factors as:
   a) water - rainfall and plant size
   b) light duration - flowering season in plants
   c) light intensity - direct sun vs. shade for house plants
   d) temperature - algae living in hot springs (54°C-80°C)
   e) minerals - nitrogen for protein synthesis, calcium for bone formation
   f) pH - acid bogs have large populations of carnivorous plants
   g) oxygen - dissolved oxygen in ponds

4. Explain that these factors are limiting factors. Limiting factors are those conditions which must be present for the survival of living things. Each organism has a tolerance for how little or how much of something it requires.

5. Explain that not all limiting factors are abiotic. Discuss the story of the Kaibab deer.

   ...Kaibab Plateau is near the Grand Canyon. In 1907, there were 4,000 deer and a substantial population of their predators; mountain lions, coyotes, and wolves. In an effort to preserve the deer, hunting was prohibited and predator control was initiated. By 1917, 600 mountain lions were eliminated. By 1926, the small wolf population was exterminated and by 1939 over 7,000 coyotes had been killed. As a result of the large death rate, the deer population increased rapidly, until there were more than could be supported by the winter food supply. By 1920, 100,000 deer were estimated to be present, but starvation during the next two winters killed 60% of the population. The decline continued until 1939 when the population of the herd reached 10,000.

   Elicit the following:
   a) What is the relationship between predator and prey?
   b) What was the limiting factor(s) for the Kaibab deer?

   What were people trying to accomplish in the Kaibab Plateau?
   The deer had exceeded the carrying capacity of the area.
   The carrying capacity tells us how many organisms can live in an area without causing natural factors to limit the population size

Enrichment

1. Using deer census information, simulate the effect of hunting on bucks and does.
2. Compare graphs of the deer population in the Kaibab Plateau to the predator population.

Lesson 52 Characteristics of Population Growth

Aim: How can changes in population be represented?

Materials

3 shoe boxes, bag of marbles, buttons

Objectives

To be able to construct graphic representations of population changes
To be able to analyze and interpret data
To apply basic arithmetic skills to the understanding of population growth

Strategies

1. Elicit the definition of population as a group of organisms of one species in a given area. Define a demographer as a person who studies populations.

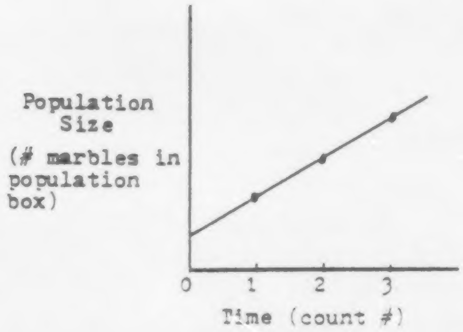
2. Label one of the shoe boxes "BIRTHS" and another "DEATHS." Have two student volunteers take positions in front of the class; one near each box. These students will follow teacher directives.

3. Label the third box "POPULATION." Place two marbles in the population box. Indicate that this is the starting population.

4. Have student volunteer place one marble at a time from the birth box into the population box. Every fifth marble, a student volunteer removes a marble from the population box and places it in the death box.

5. Assign a demographer. Stop periodically and have the demographer count the marbles in the population box and record the number on the board. Refer to these as Count 1, Count 2, etc.

6. With the help of the class, construct the following graph on the board.

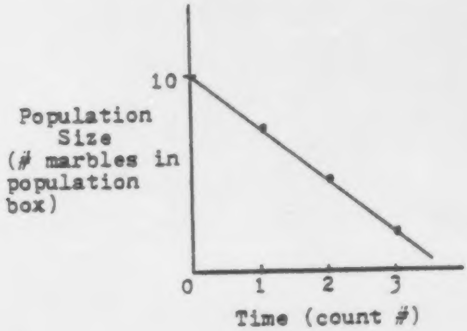


Elicit:
  a) What does this graph show?
  b) What does this tell you about the relationship between birth rate and death rate?

7. Elicit that population increases when the number of births is greater than the number of deaths.

8. Start with ten marbles in the population box. For every one added for a birth, remove two to represent deaths. Stop periodically, count and record the number on the board.

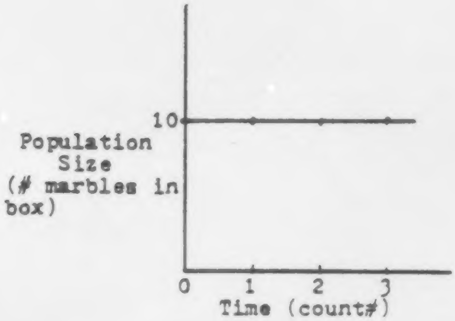
9. With the help of the class, construct the following graph.



Elicit:
  a) What does this graph show?
  b) What does this graph tell you about the relationship between birth rate and death rate in this population?

10. Elicit that population decreases when the number of births is less than the number of deaths.

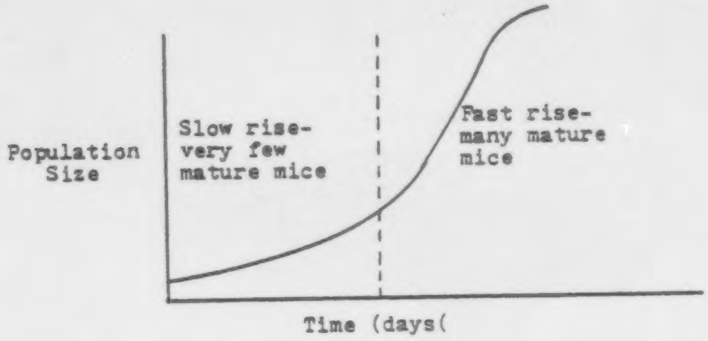
11. Repeat Procedure 8. This time, remove one marble for every marble added. Count and graph the results.



12. Elicit that the population remains the same when the number of births are equal to the number of deaths.

13. Pose the following as a hypothetical situation. A student wanted to raise mice. A male and a female were purchased. These were then placed into a cage and supplied with all their needs. Which of the graphs would you expect the mouse population to resemble?

14. It takes 21 days for mice to give birth and 35 days for baby mice to have their own offspring. How might this affect the shape of the graph?



15. Point out that among animals, the slow rise depends upon how long the gestation period, or pregnancy is, and how long it takes the animals to become sexually mature (old enough to produce offspring).

16. Explain how percents indicating birth and death rates are arrived at.

$$\text{Birth rate} = \frac{\text{births}}{1{,}000} \qquad\qquad \text{Death rate} = \frac{\text{deaths}}{1{,}000}$$

If 100 babies are born in a town of 1,000, what is the birth rate?

$$\frac{\text{births}}{1{,}000} = \frac{100}{1{,}000} = \frac{1}{10} = .1 \text{ or } 10\ \%$$

If 30 people die in the same town, what is the death rate?

$$\frac{\text{deaths}}{1{,}000} = \frac{30}{1{,}000} = \frac{3}{100} = .03 \text{ or } 3\ \%$$

17. Start with a population of 1,000 people in a town. In one year, 13 babies are born, 4 persons die, and 1 person moves into town. Calculate the following with the class

$$\text{Population Growth Rate} = \frac{\text{births-deaths} \pm \text{migration}}{1{,}000}$$

$$= \frac{13 - 4 + 1}{1{,}000} = \frac{10}{1{,}000} = \frac{1}{100} = .01 \text{ or } 1\ \%$$

18. Challenge students to describe what will happen to the population of this town if this occurs every year.

19. Make up additional examples which illustrate positive and negative growth rates. Have class interpret the meaning of each problem.

ADDITIONAL TEACHER NOTES

Lesson 53 Population Growth- Lab Activity

Aim: How can the growth rate of a population of bacteria be measured?

Materials

prepared petri dishes containing nutrient agar, cellophane tape, metric ruler, incubator (if available), growing bacterial culture (optional), glass marking pencil

Preparation of Materials

Prepare sufficient nutrient agar petri dishes for student teams. Follow instructions on label.

Objectives

To become familiar with the major forms of bacteria
To demonstrate the growth of bacteria on a nutrient agar plate
To analyze the growth rate of bacteria by the direct measurement of colony diameter

Strategies

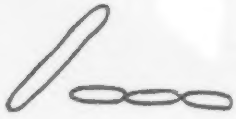
1. Define bacteria as microorganisms which are smaller than most single cells.

2. Distinguish between pathogenic (disease causing) and non-pathogenic bacteria.

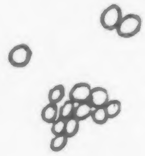
3. Elicit from the class some diseases caused by bacteria: tetanus, strep throat, tonsilitis, tuberculosis.

4. Discuss some of the beneficial bacteria with the class. Review the roles of decomposers and nitrogen fixing bacteria in the ecosystem.

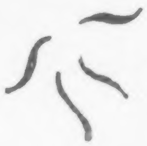
5. Discuss the classification of bacteria based upon bacterial shapes.



bacillus



coccus



spirillus

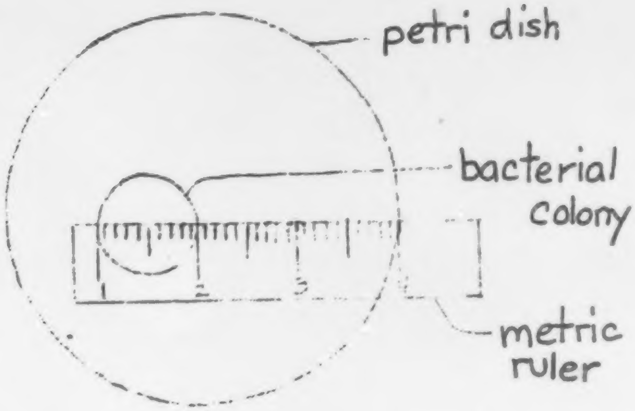
6. Elicit where bacteria might be found. Point out that bacteria can live almost anywhere; in the air, in water, in soil, inside other living things.

7. Point out that in the laboratory exercise, the class will allow bacteria from the air to settle on "food" called nutrient agar. When the bacteria land on the nutrient agar they will start to grow and reproduce to form colonies of bacteria that can be easily seen and measured.

8. Review binary fission in bacteria. Considering that bacteria can divide every 20 minutes, elicit the number of bacteria produced from a single bacterium in 2 hours.

(Optional)

9. Display a growing bacterial culture. Demonstrate the method of measuring the diameter of the bacterial colony with a metric ruler.



STUDENT LABORATORY WORKSHEET

Lesson 53 How can the growth rate of a population of bacteria be measured?

Name ______________________________ Date __________ Section _____________

Introduction

Bacteria live almost everywhere. Like other organisms they take in food, grow, and reproduce. Most bacteria reproduce by binary fission, that is they reproduce by dividing in half. When given food, such as nutrient agar, many bacteria can grow and reproduce every twenty minutes. In your activity, you will allow bacteria from the air to drop onto nutrient agar dishes. Each bacterium will grow and reproduce to form a colony. You will determine the growth rate of the bacteria by measuring the diameter of the colonies over a period of 5 days.

Procedure

1. You will be given a petri dish containing nutrient agar. Remove the dish cover and expose the agar to the air for about ten minutes.

2. Replace the cover and tape it to the bottom of the dish. Label the dish with your name and section.

3. Place the dish in an incubator or in a warm, dark place.

4. Examine the petri dish every 24 hours. Measure the diameter of the same colony with a metric ruler. DO NOT OPEN YOUR DISH. Place the ruler under the dish or on the cover to measure the diameter of the colony. Enter the colony diameter in Table 1 on the student data sheet.

5. Repeat Procedure 4 for five days. Enter your data.

6. After you have completed Table 1, complete the graph on the data sheet.

7. Your teacher will collect the petri dishes at the end of the experiment.

Questions and Conclusions

1. Some bacteria are pathogenic. Keeping this in mind, why is it important to keep your bacteria colonies in a closed dish?
2. In terms of birth rate and death rate, how would you express your results?
3. When will the bacteria population stop growing?
4. What factors in the environment would limit the growth of the following populations: wolves, oak trees, rabbits, and people?

STUDENT DATA SHEET

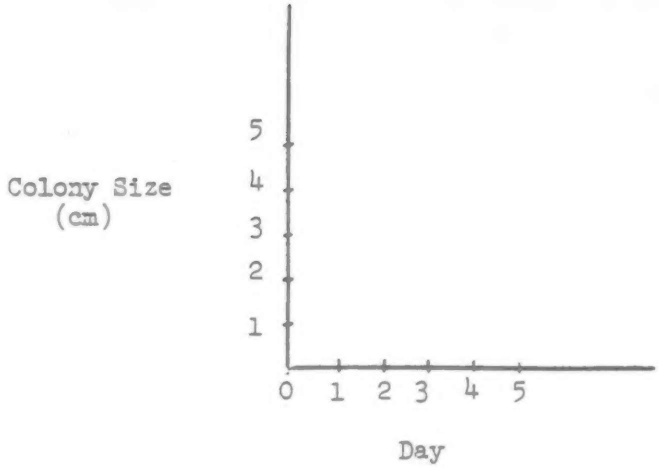
Lesson 53 How can the growth rate of a population of bacteria be measured?

Name ______________________ Date __________ Section __________

I. Table I: Growth Rate Data

Day	Colony Size (cm)
1	
2	
3	
4	
5	

II. Growth Rate- Graph



Lesson 54 Human Population Growth

Aim: How do human populations grow?

Materials

human population graphs (reproduce for distribution)

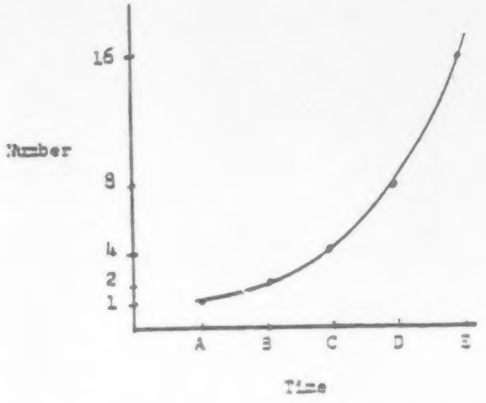
Objectives

- To develop graph reading skills
  To appreciate the changes in human population growth patterns
  To generate an explanation for human population growth patterns

Strategies

1. Distribute charts on human population growth.
2. Refer class to Chart A (Years Required To Double The Population). Encourage students to interpret what is indicated on the chart. Pay particular attention to:
   a) changes in growth rate over the past 2,000 years
   b) size of the present human population
3. Define doubling time as the amount of time it takes a population to double in size. Elicit how long it took for the human population to double in size from 1 billion to 2 billion; from 2 billion to 4 billion.
4. How does the shape of the curve differ from 1900 to 1970 compared with 1 A.D. to 1850?
5. Construct the following graph.

Time	Number
A	1
B	2
C	4
D	8
E	16



This type of growth is called exponential. Compare this to the human population curve in Chart B (Growth of World's Population). How do they compare?

6. Refer students to Chart C (Population of Developed and Underdeveloped Countries).
   a) In which countries is population increasing fastest? slowest?
   b) Elicit why population is increasing faster in underdeveloped countries. Discuss the economic importance of children in agricultural communities; lack of birth control information.
   c) Compare this to what is happening in developed countries. Discuss children as liabilities rather than assets (need support but do not contribute to family income, like farm children). Also point out the cultural and technological differences between developed and underdeveloped countries.

7. Refer to Chart D (Population Age Distribution). If the United States population continued to grow constantly, what would this graph look like?

8. Elicit those factors which might be responsible for this odd-shaped graph. Include such factors as:
   a) low birth rate during the depression
   b) post-war baby boom

9. Discuss conditions favoring less children vs. more children during the depression and after World War II.

10. Discuss conditions in the United States now. Elicit whether or not these conditions favor increased or decreased population growth.

Enrichment

Using Chart D (Population Age Distribution), determine the potential for growth in population size from the population of teenagers today.

ADDITIONAL TEACHER NOTES

CHART A Years Required To Double The Population

Year	Population	Number of years to double
	(billions)	
1	0.25	1650
1650	0.50	200
1850	1.1	80
1930	2.0	45
1975	4.0	35
2010	8.0	?

CHART B Growth of World's Population

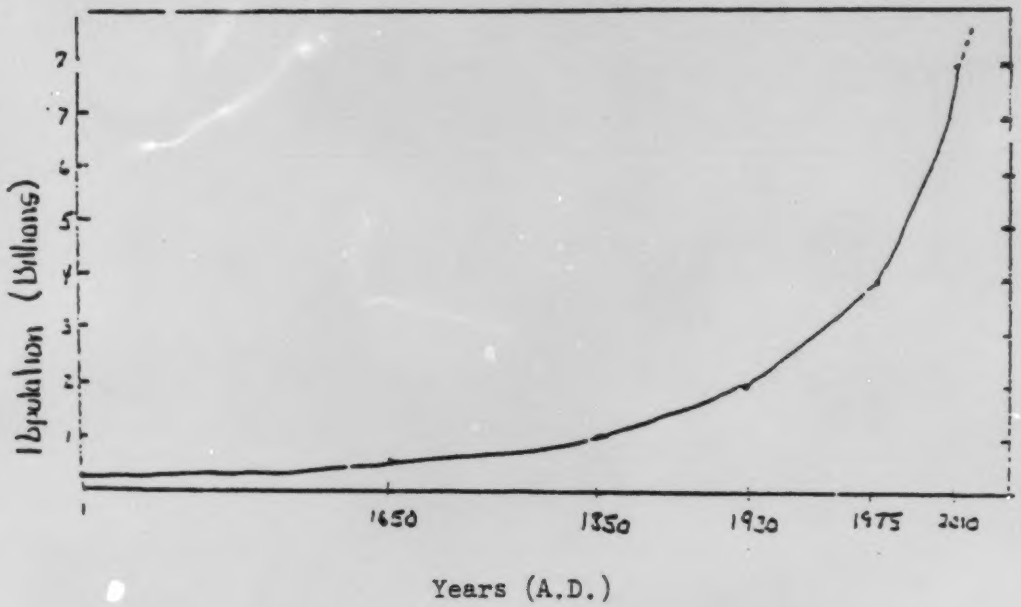


CHART C

Population of Developed and Underdeveloped Countries

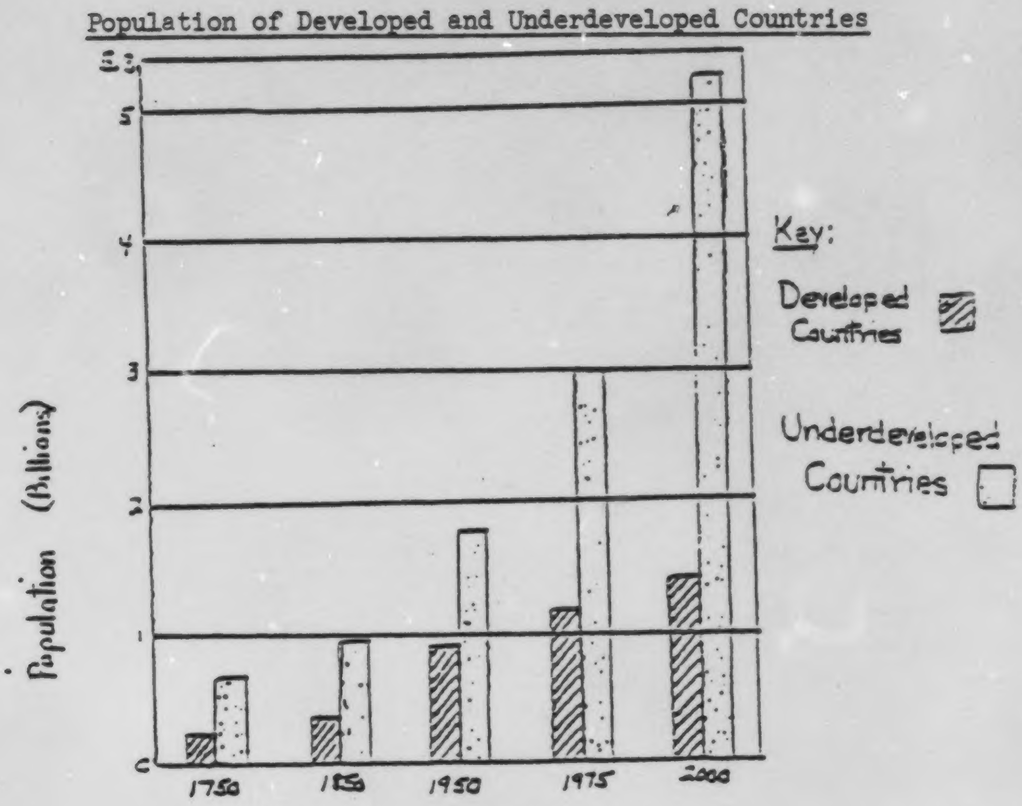
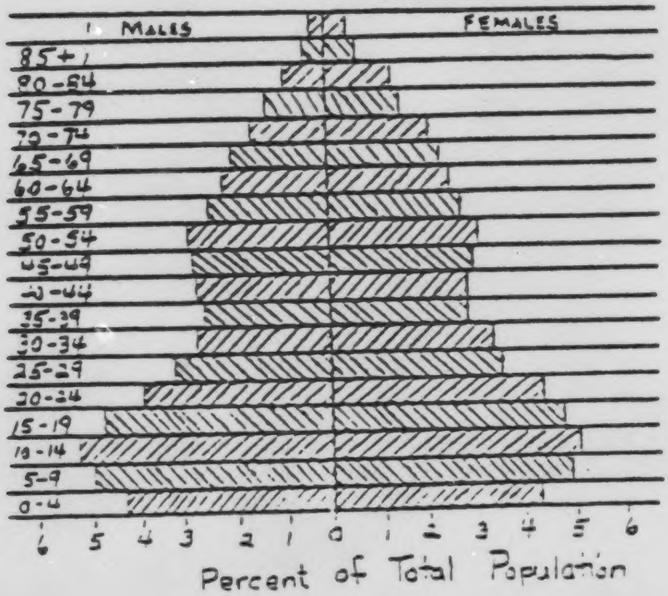


CHART D

Population Age Distribution

U. S. 1970 Population



Lesson 55 Population Density and Overpopulation

Aim: How many is too much?

Materials

4 meter sticks, masking tape

Objectives

To be able to represent population density as a mathematical expression
To be able to analyze the conditions in an overpopulated area
To apply the principles of population density and overpopulation to human populations

Strategies

1. Use the meter sticks to mark off a 1 square meter area on the floor. Tape the sticks down, or mark the floor with masking tape.

2. Explain that this area represents land that has just been opened for a housing development. Place two students in the square. Place the following table on the board.

Population	Area of Square	Population Density

3. Keep adding students, two at a time, to the square. Have a student record the data.

Population	per	Area of Square	equals	Population Density
2	per	M^2	equals	$\frac{2}{1\ M^2}$
4	per	M^2	equals	$\frac{4}{1\ M^2}$
6	per	M^2	equals	$\frac{6}{1\ M^2}$
8	per	M^2	equals	$\frac{8}{1\ M^2}$

Explain that the population per unit area may be found by using the formula:

$$\frac{\text{Population}}{\text{Area}}$$

4. Add students to the square until it becomes absolutely impossible to add any more. Try to keep students in the square for as long as possible. Elicit student complaints about crowding and discomfort.

5. Have students analyze what happened in the square.

6. Define population density as the number of individuals living in a given area.

7. In what ways may population density increase?
   a) Add more individuals through an increased birth rate or decreased death rate.
   b) Decrease the area available: e.g., A herd of 1,000 deer was living on 100 square acres. In two years, 80 square acres were used for human housing. What was the change in deer population density?

$$\text{Population Density} = \frac{\text{Population}}{\text{Area}} = \frac{1,000}{100} = \frac{10}{1}$$

or 10 deer/ square acre

$$\text{Population Density} = \frac{\text{Population}}{\text{Area}} = \frac{1,000}{20} = \frac{50}{1}$$

or 50 deer/ square acre

8. Define overpopulation as too many individuals living in a given area.

9. Discuss the effects of overpopulation on individuals. List some of the effects on the board.
   a) Increased chance of serious illness. Easier for disease-causing organisms to spread.
   b) Increased aggresion and hostility. Most animals will fight for what little space they have in an overpopulated area.
   c) Increased death rate. Disease and stress-related illnesses such as heart attack, ulcers, strokes, etc. increase because of increased tension and pressure.

10. Discuss application of these ideas to human populations.
   a) Problems of city living:
      1) increase in violent crimes
      2) increase in infant death rate
      3) increase in death from stress-related diseases
   b) Students own personal experiences with crowding and overpopulation.

Enrichment

Have students estimate the population density of a:
   a) house or apartment building
   b) block
   c) school

Lesson 56 Factors Affecting the Growth of Populations

Aim: What factors affect population growth?

Objectives

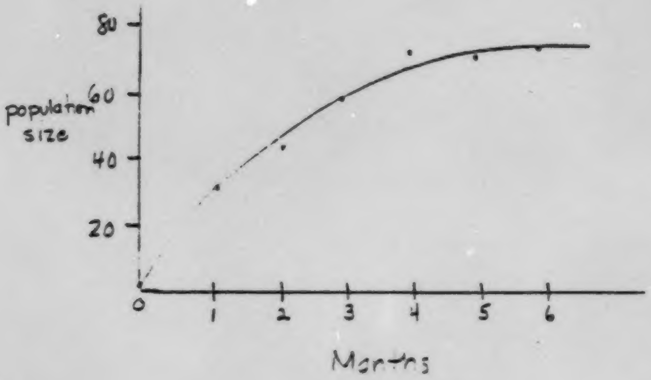
- To define the factors that limit populations
- To construct a graphic representation of limiting factors
- To be able to analyze the relationship between limiting factors and populations
- To develop the concept of "Spaceship Earth" as related to our finite resources

Strategies

1. Present the following story to the class:
   A tropical fish breeder wanted to raise guppies. He placed a male and a female in a tank, and put two pinches of food in the tank every day. As time passed, he counted the fish in the tank. These were his results:

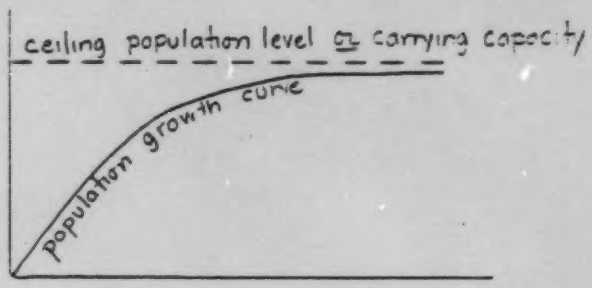
Month	Number of Fish
1	30
2	45
3	60
4	75
5	74
6	76

2. Encourage student participation in constructing the following graph.



3. How can you explain the levelling-off that occurs after four months? (Hint- only 2 pinches of food a day.)

4. Add the following to the graph:



5. Define ceiling population or carrying capacities as the maximum number of organisms that can live in a given area.

6. Elicit from the class some factors that would determine the ceiling population of an area. List factors on the board and discuss why each is important.

7. Define limiting factor as any factor in the environment that can limit population growth.

8. List some factors that specifically limit the growth of human population. Elicit how some of these differ from the factors that limit animal populations. Include religious beliefs, medical care, economics, culture, and society.

9. Elicit what might occur if a population exceeded the ceiling population or carrying capacity of an area. Discuss fighting, aggresion, and increased competition.

10. Elicit what might occur if the human population exceeded the carrying capacity. Discuss widespread hunger and disease.

11. Compare life on earth to life aboard a spaceship. Discuss the finite nature of resources on earth. Develop the concept of "Spaceship Earth."

12. Summarize by discussing the following: In nature, an animal is rarely seen dying of starvation unless something drastic (fire, flood) has occurred. Have students explain the reason for this.

Lesson 57 Some Answers To The Food Crises

Aim: Will we have enough to eat?

Materials

newspaper ads showing food prices, various meat substitutes (obtain at health food store), soy beans, peanuts, pictures of children with Kwashiorkor

Objectives

To understand the meaning of food crisis
To be able to analyze the causes of the "food crisis"
To develop an understanding for the need for alternate food sources

Strategies

1. Display photos of children suffering from starvation. Elicit possible causes of food shortage. Include drought, war, lack of proper farming methods.

2. Discuss increased population as a possible reason for food shortages.

Example: A country has a population of 1 million people and grows 10 million pounds of wheat a year. How many pounds of wheat are there for each person?

$$\text{wheat/person} = \frac{\text{wheat supply}}{\text{population}} = \frac{\text{10 million pounds}}{\text{1 million people}} = \text{10 pounds/person}$$

If the population grows to 5 million and wheat production stays the same, how much wheat is available for each person?

$$\text{wheat/person} = \frac{\text{wheat supply}}{\text{new population}} = \frac{\text{10 million}}{\text{5 million}} = \text{2 pounds/person}$$

3. Discuss the relative costs of different foods in New York City supermarkets. Use ads to get prices. List the following:

Order	Cost of Item	Item
1	$1.69/pound	meat
2	.99/dozen	eggs
3	.89/quart	milk
4	.24/pound	bananas
5	.14/pound	potatoes

4. Elicit the reasons for the difference in prices.
   a) Costs more to raise animals than it does to grow fruits and vegetables
   b) More producer organisms than consumer organisms exist in nature.

5. Discuss simple food chains or pyramids. Discuss the processing that takes place along a food chain. Elicit that energy is lost as you go along a food chain.

6. Invite students to have some peanuts and soybeans. Ask why these might be cheaper than meats. Elicit that food is more available at the producer end of a food chain than at the consumer end.

grass ⟶ cow ⟶ human   or

grain ⟶ hen ⟶ eggs ⟶ human   or

grass ⟶ cow ⟶ milk ⟶ human

7. If the preceding is true, why can't we eat grass directly? Elicit the differences in digestive systems. Discuss the need for "complete" protein to build muscles, etc. Point out that not all plant proteins are "complete" for humans.

8. Place the following on the board:

Actual Food		Equivalent Food
1 pound of meat	=	4 eggs, or 4 pounds of peanuts, or 2 pounds of soybeans

9. Invite students to sample some vegetarian meat substitutes. Discuss textured vegetable protein (T.V.P.) as a basis for meat substitutes.

10. Discuss the possibility of using one-celled plants (algae) as a food source. Mention the use of algin as a food additive in ice cream, dessert toppings, and frozen cream pies.

11. Challenge students to suggest other alternative food sources.
    a) yeast colonies
    b) bacteria (easy to grow, found all over)
    c) recycled paper- point out that cellulose in paper is made up of sugar molecules joined together

Enrichment

Have students bring in labels of foods using various alternate food sources as additives, or as the food itself.

Lesson 58 Population Control

Aim: How can we learn to deal with the problem of overpopulation?

Objectives

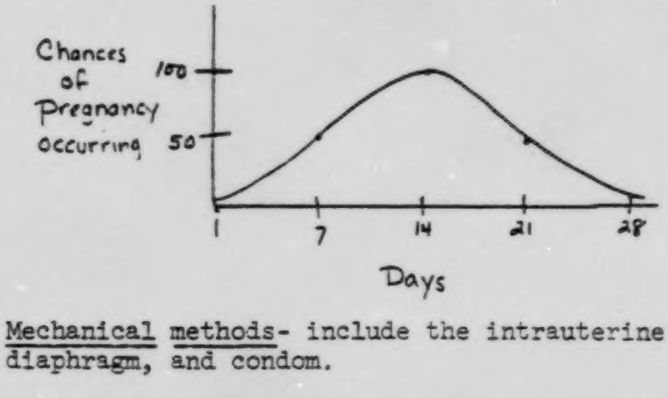
To differentiate between birth control and population control
To understand how birth control can be accomplished
To examine ways in which population size can be controlled
To suggest additional methods of population control
To understand the need for population control as a means of solving the problem of overpopulation

Strategies

1. Discuss the implications of the following statement:

   > "For generations, the conquest of nature has been accepted as man's prerogative. But man is part of nature, it being his essential environment, and unless he can find his rightful place in it, he has poor hope for survival. Man's present behavior often resembles that of an over-successful parasite which, in killing its host, accomplishes also its own death."

2. Birth control is specifically designed to limit the number of births. This requires knowledge of the reproductive process and knowledge of specific "technologies" now available.
   a) Discuss some of the reasons for using birth control methods.
   b) Discuss some of the objections to the use of birth control methods. Some common birth control methods include:
      1) Sterilization- includes vasectomy in males and tying the oviducts in females. Emphasize the permanence of these methods
      2) Rhythm method- is the restricting of intercourse to the time before or after ovulation has occurred and the egg is not fertile. This turns out to be very ineffective because of irregularities in the cycle.



      3) Mechanical methods- include the intrauterine device (IUD), diaphragm, and condom.

Explain that each of these devices prevent the sperm and egg from meeting by blocking the path of the sperm.

4) Chemical methods include the pill, foams, and gels. These generally prevent the egg from being released or kill the sperm.
5) Abortion has been used to terminate unwanted pregnancies, usually within the first three months.
   a. Which birth control methods are most successful?
   b. Why are some birth control methods objected to?

3. What are some methods of family planning?
   a) Family planning can involve a whole variety of approaches. Birth control can be used to prevent births. Family size can be used to control population.
   b) Zero population growth (ZPG), is a group that suggests that we maintain our present population size by limiting families to two children.
   c) Negative population growth (NPG), on the other hand, suggests that only a decline in population will help and this requires families with one or no children.
   d) Negative income taxes have been suggested to tax people for the children they have, rather than giving tax breaks for larger families.

Discuss that some people suggest that governments can control population by having mandatory sterilizations. Euthanasia, or mercy killing proponents, suggest this as a method of eliminating people who otherwise would die without extreme medical control.
   a) How might newer life styles affect population size?
   b) How can we get the uninterested to be concerned with population control?
   c) What effect might education and literacy have on population growth?

Enrichment

If you were the Prime Minister of a country with a serious population problem, what practical steps would you take to overcome the problem?

Lesson 59 Wildlife Population Problems: Endangered Species

Aim: Why do living things become extinct?

Materials

pictures of extinct animals, pictures of endangered animals

Objectives

To differentiate between an endangered and an extinct species
To determine the causes for extinction
To understand why some species become endangered due to human influence
To create a listing of familiar endangered species
To examine the role of competition in extinction

Strategies

1. Use pictures of dinosaurs, sabre-toothed tigers, dodo birds, and passenger pigeons to discuss extinct species. It should be emphasized that extinction indicates the death of only the known members of that species.

2. Explain that extinction is a natural process. All organisms are replaced sooner or later by better adapted, newly evolved forms. On the other hand, some species remain unchanged for many years. The horseshoe crab (Limulus) has remained unchanged for over 200 million years.

3. Show pictures of endangered species. Include: polar bears, whales, turtles, corals, whooping cranes, and osprey. Discuss the nature of populations that are in jeopardy. Discuss the assigned designations.
   a) Declining populations
   b) Rare populations
   c) Endangered populations

4. Elicit that endangered species are seriously threatened by extinction.

5. What are some reasons for species becoming endangered?
   a) Human Interference
      1. Hunting- buffalos were hunted for meat, whales for their oil, alligators for their skin, and ostriches for their feathers.
      2. Destruction of habitat- destruction of marshes left whooping cranes without a home.
      3. Threatened reproductive abilities have resulted from the effect of DDT on the calcium metabolism in birds like the pelican and osprey.
   b) Competition from new species- sometimes newly evolved species are better adapted, and replace existing species. This will often occur when people introduce exotic species.

1. Discuss how wildlife management and the development of parks and refuges help endangered species.
2. Describe how a habitat becomes essential for an organism's existence.

Enrichment

Describe some of the specializations of an organism that help it adapt to human intrusion into their habitats. Discuss also the resulting environmental changes.

Lesson 60 Wildlife Population Changes

Aim: Why do living things move around from community to community?

Materials

map of North America

Objectives

To understand the need for species migration
To examine the reasons for the decline of a species in certain cases
To appreciate the impact of imported or exotic species

Strategies

1. Discuss annual bird migration. Point out the position of Jamaica Bay on the Atlantic fly way. Indicate the flyway path on a map of North America.

2. Elicit some of the factors that cause migration. Include:
   a) Food- aquatic birds fly south for sources of food on unfrozen bodies of water in the southern United States and as far as South America.
   b) Breeding- gray whales move from arctic waters to the California Coast and back, a trip of over 9,600 kilometers.
   c) Climate factors- changes in freshwater temperature starts the movement of trout to spawning grounds in the summer.

3. Some organisms move into an area they did not previously live in. These are known as imported or exotic species. Many times they are brought in intentionally by people; however, on occasion, it is accidental. There are thousands of plants and animals that have been brought into our area of the country that are not native to the region.

   e.g. Japanese Beetles can defoliate a tree in a few minutes. They reproduce in large numbers. They are not pests in Japan, where they have natural enemies, such as parasitic wasps, round worms, and disease keeps the beetles under control.

   How can we make positive use of our knowledge of natural enemies?

   e.g. Starlings were introduced in Central Park in 1890. Now, over a billion strong, they have replaced the native Eastern bluebird.

   e.g. Killer bees escaped from a laboratory in Brazil. They are a hybrid of gentle Italian bees and vicious, honey-producing African bees. The bees have killed many farm animals and even some humans. They are moving north and replacing native bees.

4. Imported species, if they can successfully adapt to the local environment, many times replace the native species. Having no natural enemies in their new environment, they are usually very successful.

   e.g. Chestnut blight has resulted in the destruction of American chestnuts as a result of a fungus on Chinese chestnut varieties. The Chinese chestnuts are immune to the blight. The American chestnut, being susceptible, started dying-off on Long Island, and the blight has spread to trees in the surrounding area.

ADDITIONAL TEACHER NOTES

UNIT VI

URBAN ECOLOGY

Urban ecosystems are unique in that they are created by and for people. Unit VI introduces the student to the urban setting in terms of biotic and abiotic factors and relationships. Based upon previous learnings, students are asked to apply the fundamental laws of ecology and ecosystem organization to a detailed examination of the urban ecosystem. This is achieved by focusing on New York City; its historical development and present level of organization.

The issues of urban ecology are examined in light of the effect of cities on living things and the need for proper urban planning.

Lesson 61 Urban Environmental Analysis

Aim: How can a city block be mapped?

Materials

completed sample block map, ruler, unlined white paper, urban map handout

Objectives

To be able to map a typical city block
To be able to interpret data collected during a mapping exercise
To be able to apply the data gathered to environmental problem solving

Strategies

1. Distribute sample maps. Review the symbols used. Students should be made aware of the need for a scale on the map. Suggest that Avenue blocks be 20 cm long and Street blocks be 15 cm long.

2. Refer to the sample block map. This may be a previously prepared map of the school block or other familiar block. Elicit the various kinds of information shown on the map.

3. Place the following table og the board. After the table is completed, students may use the data for analysis.

Type of Building	No.	Vacant lots	Store Types	No.	Other Features	Signs, hydrants	Parking Meters

Analyze the data presented in the table. How can a population estimate be made for this block?

Population = (avg. no. ind./fam.) x (no. fam./bldg) x (no. bldgs./blk.)

4. Elicit other features students notice about buildings or about a block as they are mapping. Point out some of the inferences that can be made from such incidental data gathering. Include such items as:
   a) Energy use- number of air conditioners per building.
   b) Solid waste output- number of trash bags or cans per building.
   c) Land use- number of vacant lots plus abandoned buildings per block.

    d) Urban problems- refer to list on neighborhood survey forms.

5. Discuss the possibilities of:
    a) a composite map
    b) a total environmental analysis based upon mapping and survey techniques
    c) what city agencies or community people can best make use of the data gathered

Enrichment

1. The average air conditioner draws 8.5 amperes. Calculate the approximate amount of current used by the air conditioners on your block.
2. How might you go about estimating the amount of solid waste produced on your block? What facilities must be made for this? Are these facilities adequate?
3. What are some potential problems of vacant lots and/or buildings? What can be done about it?

ADDITIONAL TEACHER NOTES

STUDENT SURVEY FORM- THE CITY BLOCK

Lesson 61 How can a city block be mapped?

Name ______________________ Date __________ Section __________

Introduction

What do you know about your block? Each and every block in New York City tells a part of the story of the city. In order to better understand the nature of your block, you must carefully analyze its components. If you put together various types of information, you will be better able to understand how it all fits into the larger urban ecosystem.

The city is a system. As an ecological system, it contains various components of scientific, political, social, and environmental significance.

The following are directions for the construction of a survey of your block.

Part I Geography of a City Block

You will be constructing a map of your city block. Use the sample map provided by your teacher to help you construct your map. Use the ruler to draw straight lines. Make all drawings in pencil. Use two (2) sheets of plain, white, unlined paper for your map. Include the following:

1. Draw your block. Use 15 cm lengths for Streets and 20 cm lengths for Avenues. Include your street and the two bordering streets at each end of your block.

2. Indicate each of the structures on the block. Indicate all houses, apartment buildings, factories, stores, etc. Draw all structures to scale. Indicate the street number on each structure. Indicate the type of structure if it is not a house or apartment.

3. Indicate all gardens, trees, etc. using a symbol for each. Be sure to place all symbols on a key at the corner of the page. Also indicate vacant lots.

4. Indicate all city services on your block including: fire hydrants, fire alarm boxes, parking signs and meters, litter baskets, traffic lights, stop signs, caution signs, catch basins, sewers, manholes, one way signs, street lights, etc. Use symbols for each of the items located.

Part II Environmental Analysis

For each of the following items you will have to make an estimate of certain factors. You might have to observe each of the buildings for this information. You might even have to survey some of your neighbors to get answers to these questions.

1. Population of your block- Determine the number of people that actually live on your block. Construct a listing of all the house numbers and indicate the population of the building next to the house number.

2. Energy use- How many air conditioners are in each house? How could you determine the amount of current these consume? Where does the energy come from?

3. History- What do you know (or what can you find out) about the history of your block? See if you can locate and identify any landmarks.

4. What kinds of environmental problems are found on your block? Why do you consider these problems? How might these be solved?

5. What signs of environmental deterioration can be found on your block? What potential dangers might these present?

6. How would you rate the quality of your block? your community?

Lesson 62 Historical Development of the Cities

Aim: How have people created their own environment?

Materials

pictures of Neanderthal or Cromagnon people huddled in a cave, pictures of cities- old and new, maps of New York City dating back as far as possible

Objectives

To understand people's need for developing the city
To analyze the city as an area of human habitation
To recognize the relationship between changing culture and technology and the development of the cities

Strategies

1. Show pictures of cavepeople huddled in a cave. Ask students to describe what it might have been like living as a caveperson some 50,000 years ago.

2. Challenge students to explain why people choose to live together rather than separately. Elicit such responses as mutual protection, security, and the sharing of skills.

3. Place the following on the board:

   FISHING TRIBE FARMING TRIBE

   Elicit the type of relationship that might have been established between fishing people and farmers. Discuss such factors as the trading of goods and services.

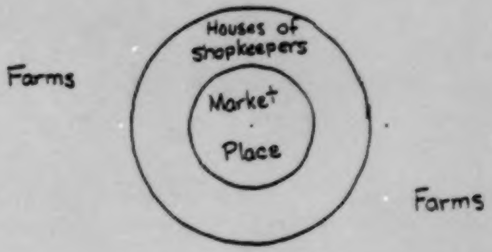
4. Discuss the development of the market place as an area for trade. Elicit from class, those services that might be offered at the market place, e.g., barber, shoe maker, potter, etc.

5. Discuss the evolution of the market place to small town. Emphasize the establishment of permanent dwellings and places of trade.

6. Discuss what other purposes the river might have served besides being a source of fish. Elicit the role of water in trade and the develpoment of towns and cities near bodies of water. Consider such cities as New York City on the Hudson River, London on the Thames River, and Paris on the Seine.

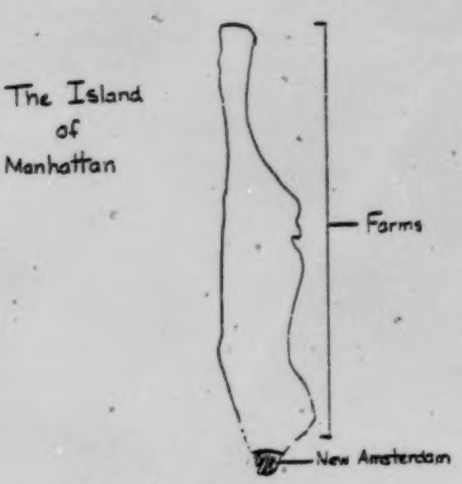
7. Ask why some people might prefer not to live in towns or villages. Guide students to an understanding that crowding and noise often discourage people from living in cities.

8. Place the following on the board:



Discuss the "Concentric Ring" arrangement of this town with the class. Define concentric ring structure as a city organized in a series of rings, the innermost rings being used for commerce and industry, the outermost ring being used for residential or living areas.

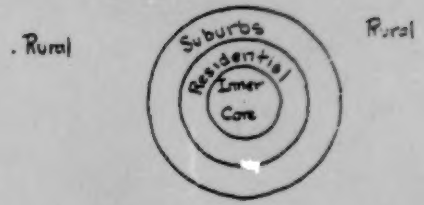
9. Trace the development of New York City as a concentric ring city. Point out that New Amsterdam originally occupied only the tip of Manhattan.



10. Based upon previous learnings, encourage students to describe how New York City has changed since 1615. Discuss such factors as increased population, increased building numbers and size, as well as increased area of the city. Elicit that all of these factors became possible as a result of new technology. Discuss the vertical development of cities in terms of constructing tall buildings for housing large populations.

11. Discuss the impact of the automobile during the 20th century. Explain that the automobile is largely responsible for changing the structure of the city from small rural areas to large urban areas.

12. Place the following on the board.


Rural
Suburbs
Residential
Inner
Core
Rural

Refer to the diagram and encourage students to describe the types of buildings that would be found within each area.

Enrichment

Have students classify their neighborhood according to what ring it belongs in. How do the buildings in their neighborhoods differ from buildings in other sections of the city?

Lesson 63 Human Habitats

Aim: How are modern cities organized?

Materials

pictures of New York City depicting change, map of eastern United States, map of United States

Objectives

To analyze the dynamic structure of a modern city
To be able to construct a model for large scale urbanization
To be able to understand the relationship between high technology and rapid urban growth

Strategies

1. Elicit the structure of the city as developed in the last lesson.

2. Discuss factors responsible for the enlargement of a city. Include such factors as:
   a) increased industry- new factories, warehouses, docks, etc.
   b) increased population- new homes, apartment houses, stores, schools, etc.

3. Challenge students to cite examples of changes in their own neighborhood, or in the school neighborhood. Reinforce this with pictures that illustrate how New York has changed.

4. Have students suggest ways in which change in the urban areas has affected people. Elicit such factors as:
   a) flight to the suburbs
   b) abandonment of buildings
   c) shifting population patterns

5. Discuss the following examples with the class:
   Forest Hills in Queens was once a quiet, almost farm-like area. About 30 years ago, builders and real estate agents began to build and sell homes and apartment houses in that area. Elicit what we might expect to find there today.
   a) stores
   b) increased traffic
   c) high population
   d) noise
   e) shopping centers

6. Define urban sprawl as an uncontrolled growth of a city caused by poor planning.

7. Elicit examples of areas in or near New York City that show urban sprawl.

8. Discuss why moving to the suburbs or away from the city is not always an answer to the problems of the city. Locate Lakewood, N.J., New York City, N.Y., and Philadelphia, Pa. on a map of the eastern United States. Elicit how each of these cities is related in terms of distance. How might the suburb of one city be affected by its proximity to another city? How might this affect people living there?

9. Define megalopolis as a string of loosely connected cities with blending suburbs. Examples of East Coast megalopoli are: Boston, Mass.; Providence, R.I.; Hartford, Conn.; New York City, N.Y.; Philadelphia, Pa.; Baltimore, Md.; and Washington, D.C. Have a student locate these cities on a map.

10. Each of these areas exhibit urban sprawl. Elicit what has made this possible. Include such factors as:
    a) improved highways and roads
    b) faster cars
    c) increased use of inter-city mass transit
    d) better and faster construction techniques

11. Discuss the establishment of other large urban areas.
    a) along the Great Lakes
    b) along the Gulf coast (Texan and Louisiana)
    c) along the Pacific coast

Enrichment

1. Encourage students to suggest reasons for leaving the city. Order these in terms of importance.
2. Ask students to name those city conveniences they would most like to have near them.

ADDITIONAL TEACHER NOTES

Lesson 64 Abiotic Features of New York City- Geology

Aim: What are the major natural features of New York City?

Materials

New York City map, pictures or slides of geological features of New York City

Objectives

To relate the subsurface features of New York City to its development
To identify some of the major geological features of New York City
To understand the need for geological features made by people

Strategies

1. Ask students to suggest what the distribution and location of skyscrappers tells us about the ground under Manhattan. Elicit that skyscrappers need a firm foundation. Explain that they must be built on solid rock (bedrock) or they might topple or sink under their own weight.

   State that in Manhattan, the tallest buildings are located around the Wall St. and Midtown areas. It it here that the bedrock is closest to the surface on this island.

2. Ask which of the boroughs is located on the mainland of the United States. Elicit that the Bronx is built up on bedrock that protrudes from the ground in many places. The bedrock can be clearly seen along many of the borough's highways.

3. On what island are Brooklyn and Queens located? Develop the concept that Long Island was formed during the last Ice Age. The glacier that covered this section of North America proceeded as far south as Long Island when it stopped. As it melted it deposited boulders, rocks, and other mineral debris forming Long Island. This ridge of mineral deposits is known as the terminal moraine. It extends the entire length of the Island and can be most clearly seen in Prospect Park in Brooklyn. Why aren't there any skyscrappers located in Brooklyn and Queens?

4. Staten Island was partially covered by the same glacier, forming several of the large hills that are found there.

5. Each borough has had its geology and coastlines changed by human engineering. For example:
   a) Bulkheads have replaced shorelines in many sections.
   b) Marshlands have been landfilled and buildings constructed upon them.

Explain that the shape of shorelines has been altered by landfill (new land where there was formerly water). Elicit such examples as

Battery Park City, Pennsylvania Avenue Landfill Park, Coney Island, etc.

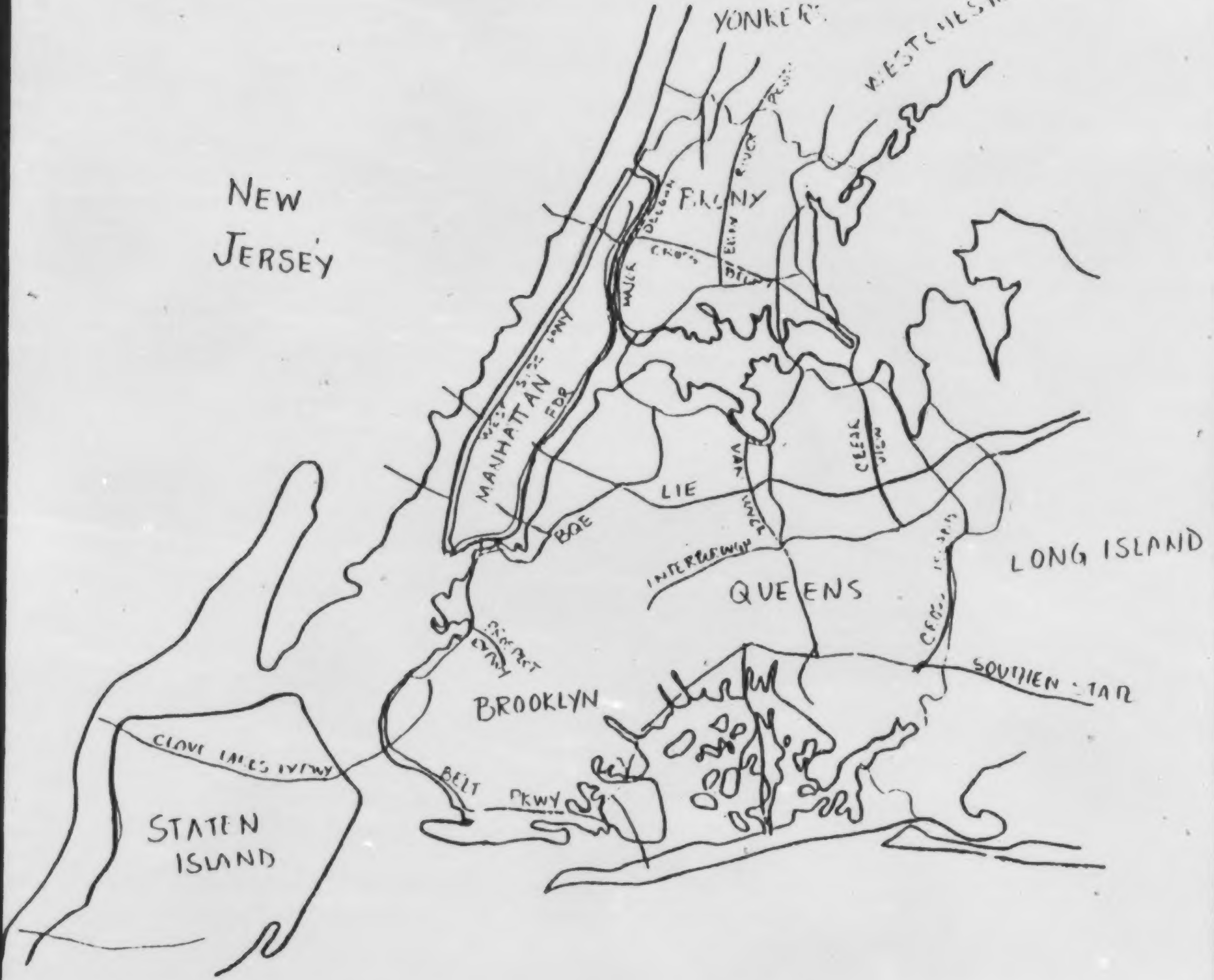
Elicit the effects of landfilling and bulkhead construction on marshland wildlife.

c) How would the construction of a groin or a jetty help prevent beach erosion? Explain that by constructing groins (perpendicular to shoreline) and jetties (parallel to shoreline), beach erosion control projects were started earlier in the century. Boulders removed from Manhattan during the excavation of the subway tunnels were used for this purpose.

Enrichment

Describe some of the geological features of your neighborhood. Is the area flat or tree covered? It is natural or constructed by people?

ADDITIONAL TEACHER NOTES


YONKERS
WESTCHESTER
NEW JERSEY
BRONX
DEEGAN
CROSS
MAJOR
BRONX RIVER
MANHATTAN
WEST SIDE HWY
FDR
LIE
BQE
VAN WYCK
CLEAR VIEW
INTERBORO
QUEENS
CROSS ISLAND
LONG ISLAND
SOUTHERN STATE
PROSPECT
BROOKLYN
CLOVE LAKES PKWY
BELT PKWY
STATEN ISLAND

Lesson 65 Abiotic Factors of the City Ecosystem

Aim: What effect does urban development have on the water cycle and city climate?

Materials

pictures of reservoirs, New York State map

Objectives

To review the water cycle and discuss changes that might occur in an urban area
To identify sources of water for New York City
To discuss the effect of pavement on groundwater supplies
To understand the need for a sewer system in an urban area
To study the microclimate of the city and its effects on precipitation

Strategies

1. Review the water cycle. Elicit that the water cycle is the movement of water from the atmosphere, into the ground and rivers, then to the oceans, and back to the atmosphere again.

2. Discuss the methods used by people to obtain water. Elicit that even today, people go down to the river or stream to obtain water. Others draw water from underground wells.

3. Elicit what happens to rainwater that falls on a field. Develop that rainwater seeps underground and is used by trees and other plants. The remaining water becomes part of underground water supplies that fill pores in rocks and other empty spaces. The top of this saturated zone is called the water table. There are numerous streams underground which filter into water-bearing layers of rock called aquifers.

4. Guide students to an understanding of where the New York City water supply comes from. Explain that because of our large needs, we have created reservoirs in upstate New York to hold water in storage. The reservoirs are nothing more than artificial lakes surrounded by vast-sloped areas, called watersheds. The reservoirs collect water which is then piped into New York City. Our major reservoirs are the Ashokan, in the Catskills, and the Croton and Kensico in Westchester. Refer to these on a map.

   Explain that many of the water tunnels into New York City are very old and in need of repair. These tunnels are inadequate for the needs of our large city.

   Challenge students to explain how water enters their house. Also, elicit what happens when large amounts of water are needed by different people at the same time.

5. Elicit how cities have affected the natural movement of rainwater. In other words, how does pavement affect downward movement? Guide students to an understanding that pavement covering the soil leaves little room for the absorption of rainwater. Explain that catch basins and storm sewers are needed to drain water out to the ocean.

6. How does the city affect climate? Elicit the effects of paved roadways, underground steampipes, and tall skyscrappers. Develop the following:
   a) A microclimate results around cities because the activity of the city modifies the climate of the immediate area.
   b) An "urban heat island" is created by rising temperatures since vegetation is not available for evaporative cooling. Winds are also affected by the many skyscrappers. Temperatures tend to be higher in the city.
   c) Precipitation is likely to increase because of the increase in air particulates.
   d) Air pollution also has some effect on the amount of available solar energy received.

Enrichment

1. Compare the temperature of the city versus the temperature of the outlying suburbs; using daily weather reports.
2. Analyze the patterns of precipitation in the city.
3. What effect will a drought have on New York City?
4. Determine the amount of open space versus paved area in your neighborhood. What effect will this have on the flow of rain water?

ADDITIONAL TEACHER NOTES

Lesson 66 Living Things in an Urban Environment

Aim: What plants and animals inhabit New York City?

Materials

slides or pictures of past and present plant and animal inhabitants of New York City

Objectives

To identify some of the common plants and animals in our city
To compare the wildlife population of the city today with the Nineteenth Century
To discuss the adaptations of plants and animals that live in the city
To identify plant and animal habitats in the city

Strategies

1. When was the last time you saw any deer, rabbits, or raccoons on your block? Have you ever seen bluebirds or woodpeckers in any trees near your home? Have you ever caught a bluefish from a pier in the city? Why not? All of these organisms lived here during the last century. Where did they go? (Illustrate typical organisms with any available pictures or slides.)

2. What kinds of plants and animals live in the city now? Large areas of the city were once covered by forests. The common city trees of today were not native to these forests. Why did this change occur?

3. Elicit those adaptations which are necessary for plants to live in the city. Include such factors as:
    a) need little light- buildings and air pollution reduce the amount of available light
    b) need little water- rainwater washes into sewers; snow is carted away and dumped
    c) tolerance for soot and carbon monoxide
    d) people walk on plants
    e) refuse is thrown on plants

4. Elicit the types of plants that can withstand these abuses. Include such plants as:
    a) Grasses- Phragmitis- (Red Grass), crab grass, foxtail grass
    b) Wildflowers (herbs)- Queen Anne's Lace, smartweeds, pepperweed, clovers, bittersweet nightshade, plaintain, dandelion
    c) Trees- ailanthus (Tree of Heaven), London Plane Tree (Sycamore), Ginko, Norway Maple, Red Oak

5. Challenge students to think of the many places, both the usual and unusual habitats, in which they have seen plants growing in the city.

6. Elicit how animals must be adapted for the life in the city. Are most of the animals "native Americans" or are they "immigrants"? Some were introduced intentionally, others entered purely by accident.
   a) Rodents
      rats- What is their native country? Originally from Europe, but have now been carried by people all around the world. What kind of habitat do rats prefer? Why? They live close to people and feed on their foods.
      Other rodents- What other rodents are found in cities? House mouse, gray squirrel

   b) Birds
      pigeons- What is their food source? Pigeons obtain food from city garbage cans and crumbs thrown by well-intentioned people. Where do pigeons build nests? They nest on windowsills and building ledges.
      English Sparrows- What are the effects of introducing an organism into an area where it has no natural enemies? One thousand English sparrows were released in Philadelphia in 1869; today they are found all over the United States and Canada, but never too far away from cities. Their population has gradually declined along with the decreased use of horses in the cities. Why do you think this happened? The seeds found in horse droppings probably served as a source of nutrition during winter.
      Other birds- What are some other birds that inhabit the city: starling, herring gull, robin

   c) Insects
      Cockroach- Fossil records of cockroaches indicate that they have not changed in 200 million years. What makes this organism so successful? Their means of escape (running and flying) and diet (almost anything including the glue in bookbindings) account for their spread around the world along with people. What are some other insects commonly found in cities?
      Other insects- mosquitoes (malarial, common, New Jersey Marsh), flies (house, horse, fruit, flesh), bedbug, lice, silverfish, flea (rat, dog, cat, human), clothes moth, ants, bees, wasps, beetles (dung, Japanese, carpet, ladybug, firefly)

   d) Arachnids- spiders, ticks, mites

   Elicit some of the more unusual habitats of the organisms listed.

Enrichment

List some of the plants and animals that live in your neighborhood. Indicate where each is located.

Lesson 67 The Effects of Cities on Living Things

Aim: How does the city affect an organism?

Objectives

To discuss the effects of pollution on the city environment
To discuss the physical and psychological stresses of crowding on living things

Strategies

1. Relate the story of the peppered moth. Before industrialization, the moths were light colored with a pattern of dark spots, making them highly camouglaged with the gray bark of trees. After pollution had darkened the trees, the moths were an easy target for predators. Then one individual was found that was almost completely black, and better able to survive. In fifty years, almost the entire population was of the darker kind.

2. Challenge students to suggest various sources of pollution found in the city. Elicit the effects of these on living things.
    a) Air pollution- Air pollutants and moisture in the air combine to form corrosive acids. These acids are strong enough to wear away the features of marble statues. What effects do you think these might have on our lungs, eyes, nose, and throat?
    b) Water pollution- In some areas of the city, raw sewage is dumped into the waterways. In all sections of the city, raw sewage is carried into the waterways after a heavy rainfall. How might this affect organisms living in these waterways? What types of organisms would this include? How would this affect the city's beaches?
    c) Noise pollution- What happens when you hear a car backfire? Noise pollution is real, but difficult to study. It can cause a loss of hearing, and may make people irritable, nervous, and frightened.

3. Discuss the possible effects of overpopulation. Elicit that crowding causes psychological effects in people that are difficult to measure. Studies on overcrowding in rat populations show that their normal behavior changes. The rats no longer take proper care of their offspring; they display increased aggresion; and they are more prone to such stress diseases as heart attack, stroke, and ulcers.

Enrichment

Why do people object to further development in urban areas? e.g., the Westway Project; the SST; the building of high-rise apartments in residential areas; nuclear power plants, etc.?

Lesson 68 Urban Planning

Aim: How might we improve urban areas?

Objectives

To discuss the role of urban planning
To understand the use of "greenbelts" in planning cities
To examine the components of planned and alternative urban developments

Strategies

1. Discuss the role of planning as shown in the destruction of natural habitats for human habitation. Elicit how the expansion of cities has affected the natural environment. Ask students whether they think that marsh or forested areas should be developed for city use. Should houses be built in Central Park?

2. Elicit some positive and negative aspects of the school community. Discuss the lack of planning that results in homes being built on marshes, fault zones, and flood plains.

3. Discuss the development of housing complexes such as Co-Op city, Starrett City and various other city housing projects. Why were these developments built? Discuss the advantages and disadvantages of these developments.

4. In some localities, whole cities have been planned beforehand. Some examples include Reston, Virginia; and Columbia, Maryland. Elicit some of the positive aspects of this type of development.

5. Ask students to explain how city planning can be used in a crowded city such as New York. Elicit that the future development of an area is based upon technical assessments and public opinion.

6. Discuss the use of "Greenbelts" to provide for open space in the crowded cities. Have students give examples in the neighborhood. What role do greenbelts have along the highway?

7. Elicit what is being done to help make the city a better place in which to live. Discuss the development of vacant lots by groups such as the Green Guerillas and other local groups.

8. Have students design their own cities. They should include all of the basic services, industry, and residents. Develop a plan for land use and zoning of the community. Discuss the possible effects of further development of the community.

9. Elicit how private organizations such as the Sierra Club, the Nature Conservancy, the National Audubon Society, and the Friends of Earth aid in the preservation of land.

10. Some people have decided that they just don't want to stay in the

city anymore. Beyond the development of suburbs which rely heavily on the city, many people have "moved back to the country." Explain why.

ADDITIONAL TEACHER NOTES

Lesson 69 Urban Ecological Issues

Aim: How does the automobile compare to mass transit?

Materials

New York City road map, New York City subway map

Objectives

To study the use of mass transit as a deterrent to urban ecological issues
To discuss the advantages and the disadvantages of the automobile
To understand the advantages of mass transit in urban areas
To discuss the improvements in mass transit that will encourage its wider use

Strategies

1. Using a road map, identify and trace the major highways in and around New York City.

   Using a subway map, identify and trace some of the major subway routes in New York City.

2. Identify and discuss the hub of the city as an area of much activity (shopping, business, dining, entertainment, etc.). Locate the hub of New York City.

   Elicit whether highway and/or subway routes provide easy access to the hub of the city.

3. Encourage students to discuss some positive and negative aspects of the mass transit system as compared to the automobile. Consider such factors as:
   a) What are some advantages and/or disadvantages of each system?
   b) Which of the systems require more energy per person for service?
   c) What are some suggested improvements that might be made in each system?
   d) How can we make N.Y.C. highways and subways more attractive?
   e) What can be done to encourage wider use of subways?

4. Elicit student reactions to the suggestions that tolls be charged on East River bridges going into Brooklyn and Queens. Consider such questions as:
   a) Who would pay the toll?
   b) How much should the toll be?
   c) How should the toll money be spent?

5. Discuss the problems of automobile congestion and pollution in New York City (especially midtown Manhattan). Elicit what might be done to decongest this area. Should automobiles be banned from midtown Manhattan? What effect might this have?

6. Los Angeles is a city that was developed for the use of major highways. What are the advantages and disadvantages of this type of development?

Enrichment

1. Compose a letter to the Chairperson of the Metropolitan Transit Authority of N.Y.C. Indicate your suggestions for the improvement of the subways and bus systems.
2. How have other cities improved their mass transit systems? (i.e., B.A.R.T. in San Francisco, METRO in Washington, D.C.

UNIT VII

ENERGY AND TECHNOLOGY

Throughout modern time, people have attempted to conserve their own energy through the invention of time and energy saving devices. The resulting technological revolution has had an ever increasing effect on natural energy resources. Unit VII traces the historical uses of energy from the use of wood and animal power, to the burning of fossil fuels and the energy of the atom.

In light of our present energy crisis, energy sources are examined as is the need to develop alternative energy sources. Throughout the unit, students are made aware of the need to conserve energy resources and appreciate the fact that energy is not an infinite resource.

Lesson 70 Modern Technology

Aim: Why do we want it?

Objectives

To be able to define material values
To be able to analyze the relationship between material values and technology
To understand the dynamic character of changing values and their relationship to the development of technology

Strategies

1. Place the following sentences on the board. Have students complete these sentences using one of the two choices give.

    1) I would rather carry groceries home
        a) in my arms
        b) in a wagon
    2) I would rather
        a) walk to school
        b) ride to school
    3) I would rather
        a) deliver a message personally
        b) use the telephone
    4) I would rather
        a) use an escalator
        b) walk up stairs
    5) I would rather
        a) change TV channels by hand
        b) use remote control

2. Discuss the reasons for each of the choices. Consider such factors as ease, efficiency, and convenience.

3. Define values as a scale of rewards we have for ourselves for doing something in a certain way. Point out that most people will continue doing something in a certain way until something better comes along.

4. Elicit that many inventions are designed to make life easier, more efficient, and more convenient. Consider how the following problems have led to inventions.
    a) It takes too long to work out math problems- the calculator
    b) Many people prefer to fly in as little time as possible- the SST
    c) It's nice to have a portable source of entertainment- the transistor radio

5. Discuss how cultural differences can often create different needs. For example, the Amish in Pennsylvania

DO NOT use radios because it violates their beliefs. But they will use better methods of milking cows. They might consider using an automatic milking machine.

6. Point out that industrial nations are more likely to develop the need for heavy machinery than agricultural nations.

7. Define technology as the application of science to meet human needs. For example, radio and television are applications of physics. The battery is an application of chemistry. Elicit other examples of technology as an application of science.

Enrichment

1. List 5 devices you have at home. What need do each of these devices meet?
2. Using a scale of 1 to 10, rate ten devices you have at home.

ADDITIONAL TEACHER NOTES

Lesson 71 Historical Uses of Energy

Aim: How have people used energy?

Materials

examples of simple machines: levers, pulleys, wheels, inclined planes

Objectives

To understand the need for the different types of machines
To introduce simple machines
To understand the meaning of work and force
To understand the source of power needed to operate machines

Strategies

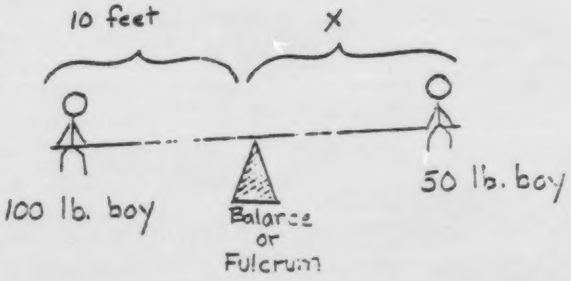
1. Discuss the meaning of technology. Elicit that technology is the application of scientific knowledge to solve practical problems. Develop the understanding that modern technology employs complex devices and sophisticated materials.

2. Refer to the cavepeople and elicit examples of the possible development and/or use of simple machines to solve problems. Consider the following:
   a) Cavepeople dragged large, flat pieces of wood piled with heavy loads. The development of the wheel might have come about when it was noticed that round, fallen trees roll easily.
   b) Heavy boulders that blocked a cave entrance had to be pushed aside. The development of the lever might have come about when it was noticed that if a person stepped on a fallen branch with a stone resting on the other end, the stone moved.

3. Explain that machines give a person a mechanical advantage to overcome a resistance.

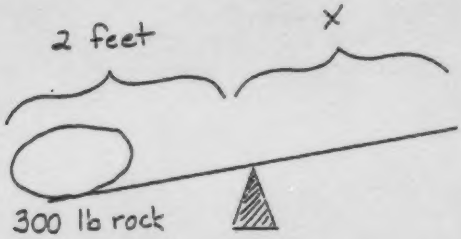
4. Use the lever as an example of a simple machine. Define a force as a push or a pull. Define work as a force acting through a distance.

5. Describe the operation of a lever. Explain that the fulcrum is the point or support about which the lever turns. Use the following problems to illustrate the advantages of a lever.



a) How far from the fulcrum of this see-sew will a boy weighing 50 pounds have to sit to balance a boy weighing 100 pounds?

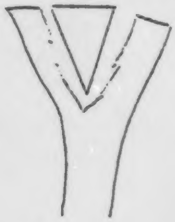
100 lb. x 10 ft. = 50 lb. x ____ ft. = 20 ft.



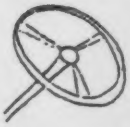
b) How far from the fulcrum would a 200 pound man have to be to lift this rock?

6. Demonstrate and explain the use of some other simple machines.

a) Wedge

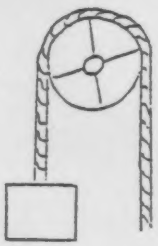


b) Wheel and Axle



c) Inclined Plane

d) Pulley



7. Discuss the sources of power used to operate these simple machines.

a) manpower- introduce the term foot pound. Define 1 foot pound as a force of one pound moving a distance of 1 foot.

b) animal power- horses, oxen, mules, etc., were used to turn wheels and operate pulleys. One horsepower is equal to 550 foot pounds per second.

Lesson 72 Types and Forms of Energy

Aim: What is energy?

Materials

wind-up toy, small electric motor, transistor radio, flashlight, hand-powered electric generator (if available), alcohol burner, safety matches

Objectives

To recognize differences between potential and kinetic energy
To understand the many different forms of energy
To demonstrate the transformation of different forms of energy
To develop definitions of energy and work
To understand the laws of thermodynamics

Strategies

1. Demonstrate each of the following:
    a) wind-up toy
    b) small electric motor
    c) transistor radio
    d) flashlight

2. Elicit that energy is needed to operate each of these devices. Define energy as the ability to do work. Explain that work is done when an object moves through a distance.

3. Have a student rub a piece of sandpaper across a block of wood. How does the wood feel? Why is it warm? Was energy lost in the change?

   Discuss the various kinds of energy involved in producing heat by rubbing sandpaper across a piece of wood.

   muscles: chemical ——→ mechanical

   rubbing: mechanical ——→ heat

4. List the Laws of Thermodynamics on the board.
    a) Energy cannot be created or destroyed
    b) Energy can be changed
    c) Every energy change is accompanied by a loss of some energy
    d) The total amount of energy in the universe is constant

Discuss the second and third laws. Elicit that the energy of moving the sandpaper across the wood was changed to heat energy.

5. Define potential energy as stored energy.

6. Define kinetic energy as the energy of motion.

7. Elicit examples of potential energy sources. Include batteries, oil, coal, and natural gas.

8. Discuss the various forms of energy and elicit examples of each.
   a) mechanical energy- a watch driven by the unwinding of a spring
   b) heat energy (molecular motion)- molecules in boiling water move around so fast that some of these leave the surface of the liquid
   c) chemical energy- energy released during a chemical reaction
   d) electrical energy- the energy of moving electrons

9. Review the energy changes that take place during the operation of a hand-powered electric generator. Elicit that the mechanical energy used to turn the crank changes to electrical energy (movement of electrons) as the coil moves through the magnetic field. This electrical energy changes to heat and light energy in the bulb.

10. Burn some alcohol or other fuel. Elicit the energy changes that take place.

$$\text{chemical} \longrightarrow \text{heat} + \text{light}$$

Define a fuel as a chemical that is burned to release heat energy. Burning (combining with oxygen) is a chemical reaction which releases heat and light energy.

Enrichment

1. Name 3 sources of energy.
2. Describe 3 types of energy changes that occur in modern machines.

Lesson 73 Energy Investigation- Lab Activity

Aim: How can energy be studied?

Materials

hand drill with bit, pencil, block of wood, large nail, claw hammer, paper clip

Objectives

To understand the relationship between kinetic energy and heat
To show how energy can be converted from one form to another
To demonstrate the relationship between friction and heat

Strategies

1. Review the activities on the student laboratory worksheets. Guide students to an understanding of what they are to do and why.

2. Instruct students to work carefully. Distribute materials and worksheets. Circulate among the students as they work through the required activities. Give assistance where necessary.

ADDTIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 73 How can energy be studied?

Name ______________________ Date __________ Section ________

Introduction

Kinetic energy is the energy of motion. Very often motion can be transferred from one object to another or the energy of motion may be changed to another form. In a clock or a wristwatch, the motion of one gear is transferred to another gear. This gear may be connected to one of the hands on the watch or clock face.

Many times one object will move against another object that does not move freely. This causes friction between the two objects. Energy from the moving object is turned into heat, and the surfaces rubbing against each other heat up. This is what occurs when you sandpaper a piece of wood and the wood and sandpaper heat up.

Materials

hand drill with bit, pencil, block of wood, large nail, claw hammer, paper clip

Procedure

1. Your teacher will give you a hand drill and a block of wood. Feel the drill bit and describe its approximate temperature (cold, cool, warm, hot). Enter this starting temperature on the data sheet.
2. Have your lab partner hold the piece of wood down firmly. Place the drill bit against the wood and drill into the wood.
3. Remove the drill bit from the wood and carefully feel the side of the bit. Describe how it feels and enter this final temperature on the data sheet.
4. Take the pencil in your hand. Feel it and describe its approximate temperature (cold, cool, warm, hot). Enter this on the data sheet.
5. Roll the pencil between your hands for several minutes. Feel it and describe its approximate temperature. Enter this on the data sheet.
6. Hold a nail in your hand. Estimate and record its approximate temperature.

7. Hammer the nail about 1/3 of the way into the wood block. Place your finger against the side of the nail. Record its approximate temperature on the data sheet. Allow the nail to cool for several minutes.

8. Feel the nail. Record its approximate temperature on the data sheet.

9. Use the claw hammer to bend the nail back and forth several times. Carefully touch the nail. Record how it feels.

10. Straighten a paper clip. Wait several seconds and feel the paper clip. Record how it feels.

11. Bend the paper clip back and forth several times. Feel the paper clip at the point where bending took place. Record your observation.

Questions and Conclusions

1. What caused each of the materials to get warm?
2. What is friction?
3. How can friction damage a machine?
4. What can be used to reduce heat caused by friction?

STUDENT DATA SHEET

Lesson 73 How can energy be studied?

Name ____________________ Date __________ Section ________

Table of Observations

Material	Starting Temp.	Final Temp.
Steel drill bit		
Pencil		
Nail		
Nail		
Paper clip		

Lesson 74 Wind, Water, and Wood as Energy Sources

Aim: What were the earliest used sources of energy?

Materials

pinwheel, plastic spoons or tongue depressors, styrofoam

Objectives

To evaluate the use of plant materials as an energy source
To discuss how people have used wind to generate energy
To understand how people have developed the use of water as a source of energy
To discuss how mechanical energy is converted into electrical energy by a generator
To understand the importance of hydroelectric power in the United States today

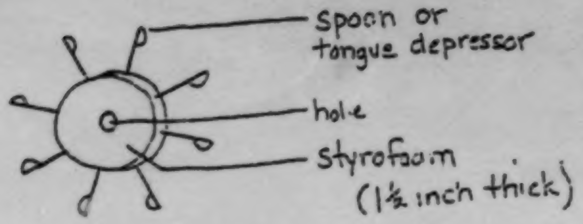
Strategies

1. Discuss wood as a source of energy. Elicit that wood was probably the first source of energy used by primitive people. Explain that wood was readily available and provided the energy needed for heating and cooking. Where does wood get its energy from? Elicit that wood comes from green plants and that through photosynthesis, plants store the energy of the sun.

2. Elicit that early uses of wind and water as sources of energy are well documented. Since the beginnings of recorded history people have used the energy of the wind to move ships and to power wind mills. Demonstrate a pinwheel. What does it resemble? Elicit the use of windmills (grinding grain into flour, pumping water used for irrigation). Elicit that in the windmill, wind energy is converted into mechanical energy.

3. Demonstrate how a rotating shaft attached to a windmill (pinwheel) can be used to turn gears. Wind conversion systems are also used to generate electricity in some areas. What are the advantages of this method of electrical production? (Wind is free, non-polluting, inexhaustible supply.) What disadvantages does it have? (Wind energy is not always available.)

4. Elicit that another early source of energy was water. Waterwheels were used for many years for the operation of grinding industries. Demonstrate the operation of a waterwheel by constructing the following device.



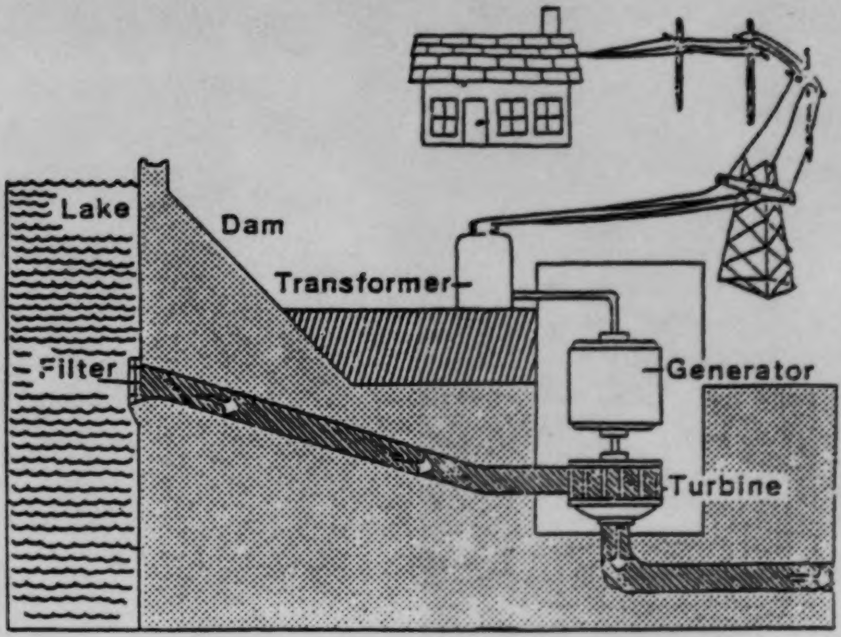
Place a pencil through the hole in the styrofoam. Allow running water to hit the blades. Elicit that water or "hydro" power can be converted into mechanical energy by turning interlocking gears.

5. Establish the use of water power to produce electrical energy. Explain that hydroelectricity is electricity produced by running water. Elicit natural locations which can be used to generate electricity. Include rivers and waterfalls.

6. Elicit how hydro power can be converted into electrical energy through the use of dams.
    a) As water moves through the dam's spillways, its kinetic energy is converted into mechanical energy by turning a turbine (a motor that uses the steadily falling water against slanted blades to turn a rotor).
    b) The turbine turns an electric generator (a machine that converts mechanical energy into electrical energy by spinning a magnet inside a coil of wire).
    c) Electrical energy is converted into high voltage electricity in a transformer and transported over high-voltage lines to customers that are sometimes hundreds of miles away.

7. How large a share of the total energy production in the United States is produced by hydro power? Elicit that water power produces only about 4% of the total United States energy supply. Explain that nearly all of the suitable locations in this country are already being used.

Electricity From Moving Water



Enrichment

Discuss the objections of environmentalists over the construction of large dams and water-control projects. e.g.:

a) Transmission over hundreds of miles to users. This means towers, high-voltage lines, and a right-of-way beneath these lines.
b) Silt settles in reservoirs, reducing storage capacity and decreasing nutrients flowing downstream to the ocean.
c) River navigation is blocked unless locks are provided.
d) Fish migration is blocked unless fish ladders are provided.

Lesson 75 Fossil Fuels

Aim: Why are fossil fuels so widely used?

Materials

fossil fuel samples, distillation apparatus, crude oil sample

Objectives

To identify the formation of fossil fuels
To describe the chemical nature of a fossil fuel
To identify the need to combust fossil fuels to release energy
To extract petroleum products by fractional distillation
To analyze the ways in which fossil fuels are used

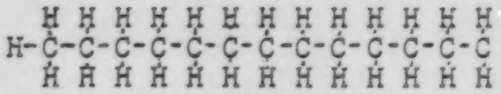
Strategies

1. Discuss the gradual formation of the fossil fuels (coal, oil, and natural gas) from dead plant and animal materials. Explain that peat is a spongy substance often found in marshes. Peat forms as plant materials decompose.

2. Elicit the characteristics of a good fuel. Include such factors as storing convenience, unburned residues, clean burning and the production of harmful by-products.

3. Explain that hydrocarbons are chemical compounds composed of hydrogen and carbon. Develop that hydrocarbons are the basic components of all fossil fuels.

   Place the following hydrocarbon molecule on the board.



$$\begin{array}{cccccccccccccc} & H & H & H & H & H & H & H & H & H & H & H & H & H \\ & | & | & | & | & | & | & | & | & | & | & | & | & | \\ H- & C- & C- & C- & C- & C- & C- & C- & C- & C- & C- & C- & C- & C \\ & | & | & | & | & | & | & | & | & | & | & | & | & | \\ & H & H & H & H & H & H & H & H & H & H & H & H & H \end{array}$$

   Explain that energy is released from such hydrocarbon molecules as the chemical bonds are broken? Why?

4. Explain the use of fossil fuels. Develop the concept that energy is released from fossil fuels by combustion, which is a process of burning. The automobile is an internal combustion engine where gasoline is burned.

   Electricity is formed by using fossil fuels to heat a boiler which turns a turbine which runs a generator. Coal or oil is frequently used to produce electrical energy in this fashion.

5. Explain how crude oil is refined.
   Fractional distillation can be used to separate the components of crude oil. Boiling crude oil results in its separation into gasoline, kerosene, fuel oil, lubricating oil, and residues. Each component is separated as it reaches its boiling point and forms a vapor.

   Demonstrate the distillation of crude oil in a distillation apparatus. Determine the temperature of the first fraction to form.

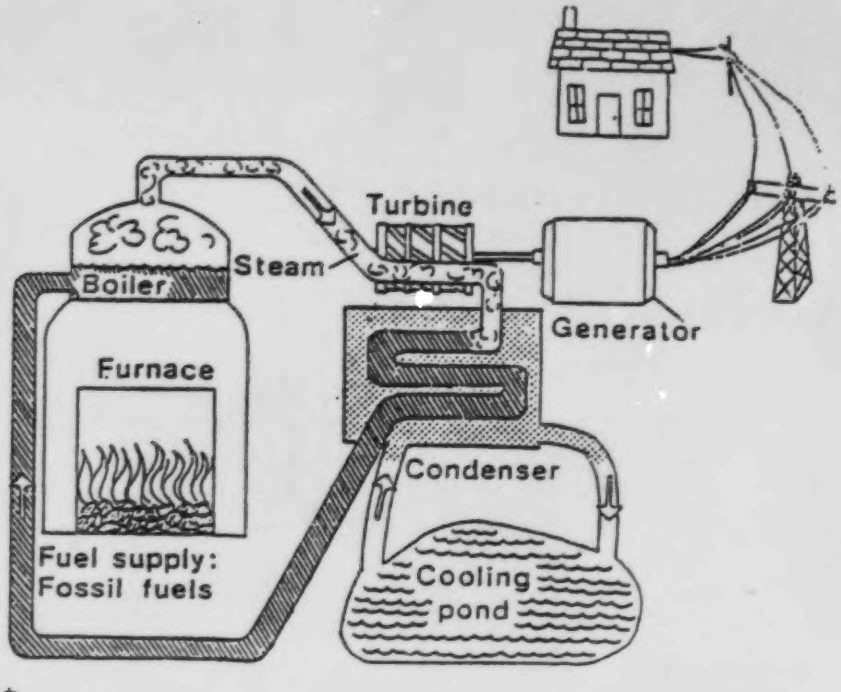
6. Explain that after combustion, fossil fuels cannot be reused. Thus, they are considered non-renewable resources.

$$\text{Fossil fuel} \xrightarrow{\text{combustion}} \text{energy} + CO_2 + H_2O + \text{wastes}$$

7. Elicit that fossil fuels are used in boilers, turbines, generators, and electric power plants.

8. Establish that electric power is measured in watts. Explain that a kilowatt hour is 1,000 watts of electricity used in one hour. Your electric meter at home measures kilowatt hours.

Electric Power From Fossil Fuels



Enrichment

1. Make a list of items that you use that require fossil fuels. What are the advantages of using these fuels?

Lesson 76 Energy Use- Lab Activity

Aim: How much energy do we use in our classroom?

Materials

foot-candle meter (if available)

Objectives

To discuss the source of energy and its use in the classroom and the school
To investigate the average use and cost of electricity in the school
To consider methods for conserving energy in the classroom
To compare the use of incandescent and fluorescent lighting

Strategies

1. Elicit that the electricity used in our schools is produced from oil, nuclear power, or hydroelectric power. State that about 25% of this electricity is used for lighting.

2. Explain that the amount of energy being used in the classroom can be calculated by counting the number of bulbs. Fluorescent bulbs are usually 4 feet (40 watts) or 8 feet (80 watts).

3. The cost of electricity is based upon the kilowatt hours used. This can be calculated by multiplying the number of watts by the number of hours used and dividing by 1,000. Place the following on the board:

$$\text{Cost} = \frac{\text{number of watts} \times \text{hours used}}{1{,}000}$$

   The number of kilowatt hours can then be calculated for a day, week, month, or year.

4. Assume that a kilowatt hour of electricity costs 10¢ (the amount varies by company, time of year, etc.). Challenge students to calculate the cost to power the classroom for a day, week, month, and year.

   How much could be saved by turning off some of the lights in the classroom?

5. Given that one barrel of oil produces about 475 kilowatt hours of electricity; have students calculate the amount of oil required to power a single classroom.

6. Discuss the differences in lighting between an incandescent and a fluorescent light bulb. Demonstrate the measurement of light produced using a foot-candle meter. Assuming that a fluorescent bulb throws off about 5 times as much light as an incandescent bulb, calculate the saving in energy by placing fluorescent fixtures in places that now have incandescent bulbs.

7. Distribute student laboratory worksheets and data sheets. Circulate among the students as they perform the required activities. Encourage students to work independently.

Enrichment

1. Calculate the amount of energy required to light your home or apartment. (Don't forget the lights outside your door.) How much does it cost to run the lights at home for a week, a month, a year?
2. What percentage of your electrical use is for lighting? How does its cost compare to your calculations?
3. How much energy is required to power your T.V. set or the other appliances in your home? (Hint: look for energy use information on the appliance.)

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 76 How much energy do we use in our classroom?

Name ________________________ Date ____________ Section _________

Introduction

Each time we walk into a room we usually flip on a light switch. Where does the energy come from that powers the lights in a room? How much does it cost to power a light bulb, a whole room of light bulbs or even a whole school building of light bulbs?

In today's activity, you will calculate the amount of energy used for lighting a room. You will also calculate the cost of this energy based upon the average cost for electricity.

The amount of energy required to power a bulb is a watt. The kilowatt is the standard unit of measurement for the amount of energy used. The number of kilowatts will be considered per hour of use. By calculating the number of bulbs and the amount of electricity used, we can calculate the cost of lighting a room.

Comparisons can also be made based on whether fluorescent or incandescent bulbs are used. It is important to note that more electricity is required for incandescent bulbs to provide the same amount of lighting as fluorescent bulbs.

Considering the cost of all the energy we use, how can we save energy? Do we need all the lights we usually turn on? How can schools and homes be better designed for conserving energy?

Materials

meter stick

Procedure

1. Measure the length of the fluorescent bulbs in the classroom. Four foot long bulbs require 40 watts while eight foot long bulbs require 80 watts. If your classroom uses incandescent bulbs, your teacher will tell you the wattage of the bulbs that are being used.
2. Count the number of bulbs in the room. Enter this on the data sheet.
3. What is the wattage of the bulbs being used? Enter this on the data sheet.
4. Calculate the total watts used. Use the formula on the data sheet.

5. Calculate the amount of energy used by multiplying the number of watts by the number of hours used.

$$\text{Watts} \times \text{hours} =$$

Enter this on the data sheet.

Divide this number by 1,000 to determine the number of kilowatt hours.

$$\frac{\text{Watts} \times \text{hours}}{1{,}000} = \text{kilowatt hours}$$

Enter this on the data sheet

6. How many kilowatt hours of electricity does your classroom require in a day, a week, a school year?

7. If each kilowatt hour costs about 10¢, how much does it cost to run the lights in your classroom for a day, a week, a school year?

$$\text{Kilowatt hours} \times \text{cost per kwh} = \text{total cost}$$

8. If a barrel of oil supplies 475 kilowatt hours of electricity, how much oil is required to light your classroom for a day, a week, a school year?

$$\frac{\text{kwh}}{475} = \text{barrels of oil}$$

Observations and Conclusions

1. How can we cut down on the amount of energy we use?
2. Why do utilities charge more for electricity during the summer months?

STUDENT DATA SHEET

Lesson 76 How much energy do we use in our classroom?

Name ______________________ Date __________ Section _________

I.

______ x _____ = __________

Number of bulbs x watts = Total watts used

II.

$$\frac{\text{Watts x hours}}{1{,}000} = \underset{\text{kilowatt hours}}{\underline{\hspace{3cm}}}$$

III. Kilowatt hours per day = _______

Kilowatt hours per week = ______

Kilowatt hours per year = ______

IV.

____________ x ____________ = __________

Kilowatt hours x cost per kwh = Total cost

Per day ______

Per week _____

Per year _____

V.

$$\frac{\text{kwh \_\_\_\_}}{475} = \underset{\text{barrels of oil}}{\underline{\hspace{3cm}}}$$

Per day ______

Per week _____

Per year _____

Lesson 77 Energy Shortages

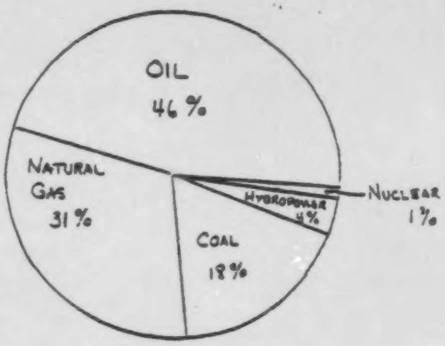
Aim: Why are we short of energy?

Objectives

To identify how fossil fuels are used
To determine the amount of our present fossil fuel supplies
To determine the demand for fossil fuels
To understand the reasons for an energy shortage

Strategies

1. Explain that fossil fuels are our major source of energy. Elicit some uses of fossil fuels.



2. Explain that fossil fuels play a major role in our lives. Elicit the major users of fossil fuels. Include:
    a) industry- 32%
    b) utilities- 25%
    c) transportation- 24%
    d) home and commercial use- 19%

3. Elicit some major factors which might account for the present fossil fuel shortage. Explain that we depend upon fossil fuels for about 95% of our energy. Guide students to an understanding that fossil fuels are non-renewable and are being used up faster than they were formed.

4. When will we run out of fossil fuels? Considering our present technologies and our knowledge of available sources we have reserves of oil for about 25 years, natural gas for 20 years, and coal for 500 years.

5. Challenge students to explain why coal is not used more widely. Elicit that coal is one of our most important minerals. Anthracite, bituminous, and lignite are types of coal. While anthracite would be the best to use, it is least abundant and slow burning. Bituminous coal is the most widely used. Lignite is the least efficient form of coal. Coal offers several drawbacks since much of it contains sulfur which forms poisonous gases.

6. Discuss the increasing need for energy in modern society. Emphasize our increasing use of electrical energy and the loss of energy in producing it.

7. Ask students how recent events highlight our energy problem. Discuss such questions as:
   a) Are the reported shortages real?
   b) What effect have politics, big business and international diplomacy had on our energy supplies?

Enrichment

1. If energy can't be destroyed, how come we have an energy shortage today?
2. Why is our present energy situation a dilemma?
3. What alternatives are available?

ADDITIONAL TEACHER NOTES

Lesson 78 Solar Energy

Aim: How can we use the energy of the sun?

Materials

radiometer, 2 thermometers, aluminum foil, pictures of solar homes and solar collectors

Objectives

To define radiation or how the sun produces radiant energy
To understand the kinds of energy given off by the sun
To identify ways which can be used to capture solar energy
To understand how solar energy can be gathered at sea

Strategies

1. Place a radiometer on a windowsill so that it can be observed by the class. Discuss the source of power used to turn the vanes of the radiometer. Have students note the surface colors of the vanes. Explain that unequal heating causes kinetic motion.

2. Establish how energy is produced by the sun and how it is transmitted to earth. Explain that thermonuclear reactions on the sun produce electromagnetic waves (solar radiation) which is emitted by the sun.

3. Elicit that electromagnetic energy emitted by the sun includes light energy, ultraviolet light, infrared, and other forms of energy.

4. Explain that plants capture and use solar energy to produce food and oxygen during photosynthesis. In this series of reactions, light energy is changed to chemical energy. In a greenhouse, sunlight is effectively captured and trapped with the glass roof.

5. Use two thermometers. Cover the bulb of one with a piece of aluminum foil. Place both thermometers near a window. Elicit from the class:
    a) Will the temperature change?
    b) Which thermometer will show a greater change (if any) and why?

   Explain that the earth's surface receives an average of 58 BTU's or 17 watts per hour per square foot of solar radiation.

6. Elicit how we can use existing ideas to capture solar energy. In other words, what techniques will enable us to increase our intake of solar energy? Explain the structure and function of solar collectors.

7. Challenge students to explain how the ocean surface might aid in gathering solar energy. Discuss the nature of the ocean surface in reference to the absorption and reflection of light energy. Ask whether it would be practical to design a solar collector for use in the ocean

8. Explain that solar cells convert light energy into electrical energy. These devices have been used extensively in spacecraft and weather satellites. However, they are costly and only about 10% efficient.

10. Discuss some of the advantages and disadvantages of using solar energy.
    Advantages
    a) inexhaustible supply
    b) clean and non-polluting
    c) free supply
    d) cost of installation and maintainance is inexpensive

    Disadvantages
    a) require a great deal of space
    b) cloud cover often blocks direct sunlight
    c) initial installation is expensive
    d) difficult to store solar energy at this time

Enrichment

1. Describe the relationship between solar energy and fossil fuels.
2. What features would you include in a "solar collector"?

ADDITIONAL TEACHER NOTES

Lesson 79 Solar Collectors- Lab Activity

Aim: How can we design a simple solar collector?

Materials (for each team)

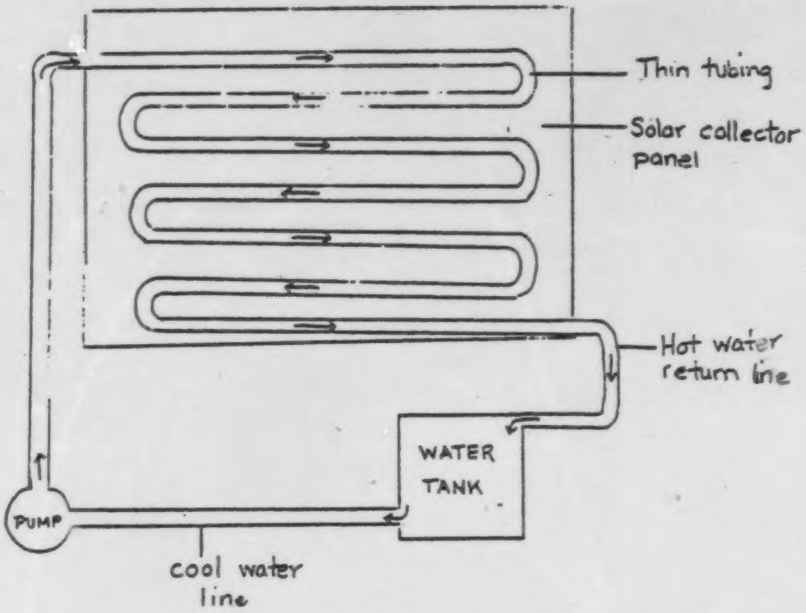
60 cm x 60 cm cardboard carton or shoe box, aluminum foil, liter container, black construction paper, scissors, masking tape, thermometer

Objectives

To analyze the feasibility of solar powered homes
To design and construct a simple solar collector
To demonstrate the function of a solar collector to heat a liter of water

Strategies

1. Discuss the function of a solar collector. Refer to the diagram of the solar collector. List and discuss the major features of the system.



2. Encourage students to design and draw a model solar collector that will efficiently heat a liter sample of water. Check the design and remind students of the limitations of available materials.

3. Provide the students with the materials necessary to construct their model solar collector. Distribute worksheets and circulate among the students.

4. Arrange for students to test their models outside of the classroom. Encourage students to measure temperature changes carefully. (Small solar collectors may be constructed in shoe boxes and placed on a sunlit windowsill if going outdoors is not feasible.)

5. After the model solar collectors have been tested, record the temperature changes found by each group.

6. Refer to the diagram of the solar collector. Describe its operation. Explain that cool water is circulated through the solar collector panel by the pump. As the water passes through the thin tubing in the panel, it absorbs heat energy from the sun. The heated water then flows through the hot water return line to the water tank. Hot water flowing through the line may first flow through radiators in a building to provide heat. At night, the tank may be used as a source of heat and hot water.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 79 How can we design a simple solar collector?

Name ______________________ Date ____________ Section ______

Introduction

Many solar collectors work by heating up water or some other liquid. Liquid heated in the collector can be used to heat a home, a factory, or an office building. Solar heating is the cleanest, cheapest method of heating available. Nothing is burned, no pollutants or waste products are produced, no fuel is used in heating the liquid. Although solar heating has been available for many years, it is only recently that is has been used widely in homes and offices. You will design your own solar heater collector. Your teacher has provided you with boxes or cartons to work in, and various materials that can be used to line your carton and the outside of the water container. Each group of students may design up to four different types of collectors depending on the materials available.

Materials

60 cm x 60 cm cardboard carton or shoe box, aluminum foil, liter container, black construction paper, scissors, masking tape, thermometer

Procedure

1. Design a model solar collector using the materials available. Draw your collector on the data sheet.
2. Write a brief description of your collector on the data sheet.
3. Carton collectors may be tested outside. Shoe box models may be placed on a sunlit windowsill.
4. Measure the temperature of the water in your container before you place it in the collector. Enter this temperature on the data sheet.
5. Place the container in the collector. After 20 minutes, record the temperature and enter it on the data sheet.

Post Laboratory Questions

1. How well did your collector work?
2. What changes or improvements would you make if you were to redesign your collector?
3. Describe several uses for solar heat.

STUDENT DATA SHEET

Lesson 79 How can we design a simple solar collector?

Name ______________________ -Date __________ Section __________

I. Solar Collector Design

Solar Collector Design Drawing

II. Solar Collector Description

____

____

____

____

____

____

III. Temperature Measurements

Starting temperature °C ______

Temperature after 20 minutes °C ______

Lesson 80 Nuclear Chemistry

Aim: What is radioactivity?

Materials

Periodic Table of the Elements

Objectives

To review the structure of the atom
To relate the atomic weight to the existence of isotopes
To understand radioactivity and the types of radiation
To describe radioactive decay
To understand the effects of radioactive isotopes in environmental cycles

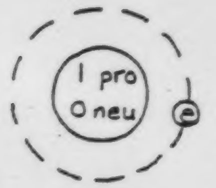
Strategies

1. Use the Periodic Table of the Elements to review the following:
    a) structure of the atom: nucleus (protons and neutrons) and electrons
    b) atomic weight: the number of particles in the nucleus (protons and neutrons)

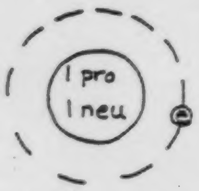
2. Instruct students to examine the atomic weight of several elements, e.g., hydrogen, carbon, uranium, and strontium. Point out that the atomic weight for each of these elements is expressed as a decimal number. Challenge students to explain why.

3. Elicit that all of the atoms of an element are alike in all ways except one; atomic weight. The number of neutrons in an element may vary from atom to atom. Atoms that have the same number of protons but varying numbers of neutrons are referred to as isotopes.

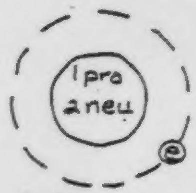
4. Explain that there are three different isotopes of hydrogen. Draw and label these on the board.



protium
(ordinary hydrogen)



deuterium



tritium

Explain that natural elements are a mixture of all of the known isotopes for that element. For example, hydrogen is 99.985% protium, 0.015% deuterium, and less than 0.001% tritium.

5. The atomic weight of hydrogen is listed as 1.00797. This is because the atomic weight of an element is the average of the atomic weights of the nuclei of all the atoms (isotopes) of that element.

6. Guide students to an understanding that many isotopes are unstable. They will change into other isotopes of the same element or into different elements. This is known as radioactivity. Radioactivity involves the spontaneous, uncontrolled decay of an atomic nucleus with the emission of particles and rays. Collectively, the emission of these particles and rays is referred to as radiation.

7. Discuss the following types of radiation.
    a) Alpha particles: these particles are the nuclei of helium atoms. They are composed of two protons and two neutrons. Alpha particles cannot penetrate solid objects. In fact, they may be stopped by aluminum foil or a sheet of paper. They travel at approximately one-tenth the speed of light.
    b) Beta particles: these are actually streams of high speed electrons. Beta particles may penetrate some solid objects, but they can be stopped by aluminum sheeting. Beta particles travel at nearly the speed of light.
    c) Gamma rays: these are electromagnetic waves or vibrations similar to light or X-rays. Gamma rays are the most penetrating radiations given off during radioactive decay. They are very destructive to human tissue and can only be stopped by thick lead or concrete.

8. Explain that although atoms of all radioactive substances continually decay, it is not possible to predict when a specific atom will decay. The rate at which a radioactive substance decays is known as its half life.

9. The half life of an element is the amount of time it takes for one-half the atoms in a sample to decay into another form.

Examples of half lives:
tritium into protium......12.3 years
C-14 into N-14............5,730 years
I-131 into I-127..........8 days

How much of the original amount of radioactive I-131 will remain after 8 days? (50%). After 16 days? (25%), etc.

10. Explain that some radioactive substances have been added to the environment by people, and have been taken up into the food chains. An example is strontium- 90 (Sr- 90), whose half life is 27 years. Strontium- 90 is part of the fallout (mixture of radioactive wastes) released from nuclear reactions. In time, its particles gradually settle to the surface of the earth. If a cow grazes on an area contaminated with Sr- 90, the substance accumulates in the bones and becomes concentrated in the milk. How might this affect people who use dairy products?

Enrichment

The half life of C-14 is 5,600 years. Discuss the carbon dating technique, i.e., the application of the theoretical half life of C-14 to determine when an organism lived.

ADDITIONAL TEACHER NOTES

Lesson 81 Nuclear Energy

Aim: What is a nuclear reaction?

Objectives

To understand the nature of a nuclear reaction
To identify some of the elements used as nuclear fuels
To develop and understand the role of a chain reaction in a nuclear power plant
To understand the nature of a nuclear fusion reaction

Strategies

1. Discuss the kind of explosion that was used at Hiroshima at the end of World War II. Elicit that the explosion was nuclear and that the "explosive" used was uranium.

2. Explain that uranium is not really an explosive. It is a very unstable element that will undergo radioactive decay. During this decay, tremendous amounts of energy are released.

3. Develop the idea that to trigger the reaction, a neutron is fired into an isotope of uranium; U-235. Uranium (92 protons) is split into 2 smaller atoms: barium (56 protons) and krypton (36 protons). The splitting of the larger atom into two smaller atoms, is known as a nuclear fission reaction.

4. Explain that a similar reaction is used inside a nuclear reactor to generate electricity. Here the reaction occurs on a smaller, more controlled scale.

5. Guide students to the understanding that once the nuclear reaction is started, it continues until all of the nuclear fuel is used. Explain that a fission reaction is a chain reaction. The products of the first reaction are used to start the next series of reactions, which trigger a third series, and so on.

6. Discuss the nuclear fission reaction. Explain that a neutron bombards the rare U-235 isotope, (only 0.7% of uranium is U-235). As fission occurs in U-235, the neutrons emitted bombard the U-238 which surrounds the U-235 (U-238 is more common than U-235; 99.3% of uranium is U-238). Through neutron capture, some of the U-238 changes to U-239. U-239 turns into neptunium-239 through a process of radioactive decay (transmutation). Neptunium-239 can also be used as fuel for a nuclear reactor.

7. The mass of the barium, krypton, and neutrons is slightly less than the original uranium nucleus. The missing matter has been converted into energy.

8. Optional nuclear equations:

$${}_0n^1 + {}_{92}U^{235} \longrightarrow {}_{92}U^{236} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + \text{energy}$$

neutron + U-235 → U-236 (unstable) → barium + krypton + 3 neutrons + energy

Or, since most of the uranium is U-238, a new element can be formed:

$${}_0n^1 + {}_{92}U^{238} \longrightarrow {}_{92}U^{239} \longrightarrow {}_{93}Np^{239} + {}_{1}{-3}^{0}$$

neutron + U-238 → U-239 (unstable) → neptunium + beta particles

$${}_{93}Np^{239} \longrightarrow {}_{94}Pu^{239} + {}_1e^1$$

neptunium-239 → plutonium-239 + beta particle

9. Elicit how energy is released on the sun. Explain that the energy of the sun comes from nuclear reactions. These reactions are triggered by the high temperature of the sun and are known as thermonuclear reactions, or fusion reactions which occur continuously.

10. In a nuclear fusion reaction two nuclei of hydrogen atoms collide and join (fuse), forming a helium nucleus. The resulting helium nucleus contains less mass than the original hydrogen nuclei. The missing matter has been converted into energy.

11. In order for nuclear fusion to occur on earth, several problems must be overcome since the hydrogen nuclei resist fusion (they have positive charges which repel one another). To get these nuclei to join, they must collide at very high speeds. For this to occur, the temperature of hydrogen must be similar to that of the sun (100 million degrees Celsius).

12. Optional nuclear equation:

$${}_{1}H^{2} + {}_{1}H^{3} \longrightarrow {}_{2}He^{4} + {}_{0}n^{1} + \text{energy}$$

deuterium + tritium ⟶ helium + neutron + energy

13. Has a nuclear fusion reaction ever occurred on earth? The explosion of a hydrogen bomb (H-bomb) is an example of a nuclear fusion reaction. How were scientists able to produce a sufficient temperature for this to occur? By first exploding an atomic bomb (A-bomb-uranium fission) huge amounts of heat were produced to cause a fusion reaction.

Enrichment

Discuss how Einstein predicted how much energy would be produced in a nuclear reaction by his equation $E=mc^2$.

Lesson 82 Nuclear Power Plants

Aim: How can nuclear energy be used to generate electricity?

Materials

illustration of nuclear generating station (reproduce for class)

Objectives

To understand the design of a nuclear reactor
To identify the function of the parts of a nuclear reactor: carbon block, fuel cells, control rods, cooling system, shielding
To understand how nuclear energy is used to create electrical energy
To discuss the hazards and safeguards in the functioning of nuclear reactors
To discuss the problems associated with the disposal of radioactive wastes.

Strategies

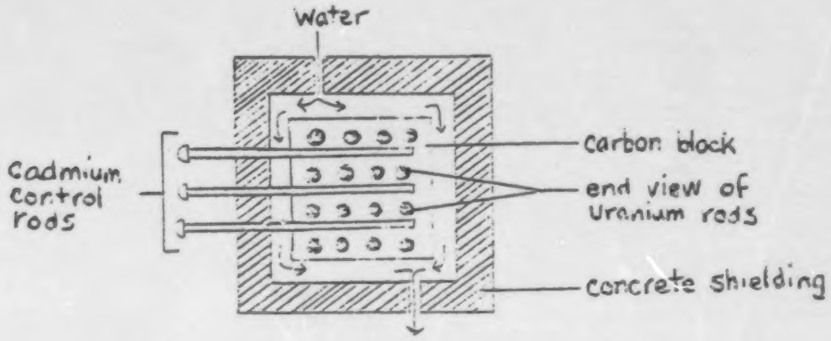
1. Explain that nuclear explosions do not occur inside of a nuclear power plant. The chain reaction that occurs is controlled and proceeds at a very slow rate. Elicit that a nuclear explosion is uncontrolled and that most of the energy is released at once, causing the explosion.

2. Discuss critical mass. Explain that a critical mass is the minimum amount of energy needed to sustain a chain reaction. In a fission bomb or nuclear reactor, a chain reaction will not occur if the parts of uranium are kept separate from one another. This is true because each part is smaller than the critical mass.

3. Discuss a typical nuclear reactor called a uranium pile. Explain that a uranium pile consists of the following:
   a) large mass of carbon blocks containing long, tubular holes spaced at certain intervals.
   b) fuel cells: chemically pure uranium rods sealed in aluminum. These are inserted into some of the holes in the carbon block. The uranium provides the fuel for the chain reaction.
   c) control rods: Cadmium rods which are inserted into the remaining holes in the carbon block. Cadmium is a good absorber of neutrons. When the cadmium rods are fully inserted, they absorb so many neutrons that the chain reaction stops. As they are gradually pulled out, they absorb fewer neutrons, allowing the chain reaction to proceed more and more rapidly.

d) a cooling system, consisting of water circulated in pipes through the reactor. This keeps the reactor from becoming dangerously hot.
e) The whole reactor is surrounded by a thick wall of concrete shielding to prevent radiation from escaping from the core.

4. Draw a nuclear reactor on the board.

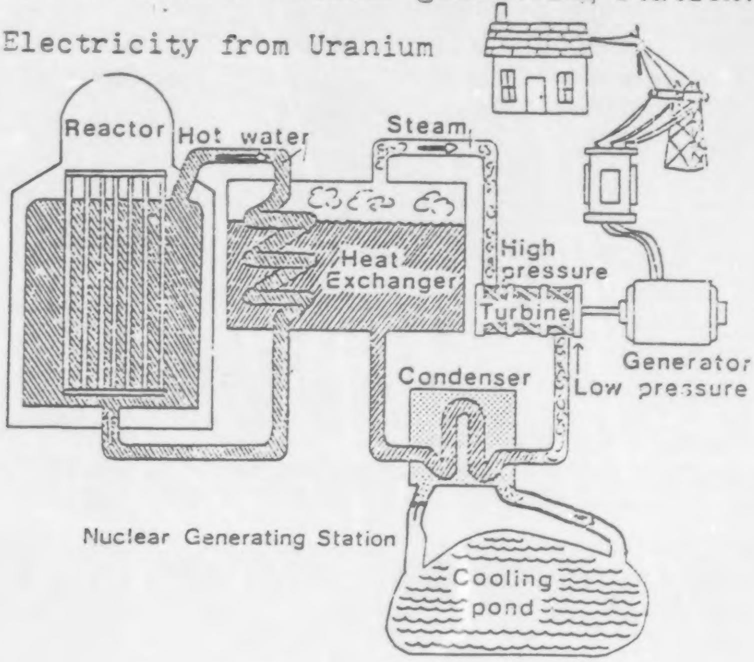

Water
Cadmium control rods
carbon block
end view of Uranium rods
concrete shielding

URANIUM PILE NUCLEAR REACTOR

Explain that heat energy given off by the reactor is used to generate electricity. The water that cools the reactor passes through tubes inside the steam generator. This heats the water. Steam from the generator is piped into a turbine which turns a generator, producing electricity.

5. Distribute illustration of nuclear generating station.

Electricity from Uranium


Reactor
Hot water
Steam
Heat Exchanger
High pressure
Turbine
Generator
Condenser
Low pressure
Nuclear Generating Station
Cooling pond

Discuss why the water that is used to cool the reactor core is not used directly in the turbine. Why must the water (coolant) be made to heat additional water in the steam generator? Explain that the coolant is slightly radioactive and cannot be used directly.

6. Explain that during emergency situations, the cadmium rods are fully inserted. This stops the reaction completely.

7. Hold a class discussion regarding opposition to the construction of nuclear reactors. Elicit that radioactive wastes are produced by fission-type nuclear power plants. The resulting problems include how these wastes are to be:
    a) stored
    b) reduced in volume
    c) disposed of

    Remind students that these wastes will remain radioactive for hundreds or thousands of years. Explain that the location and storage material of radioactive wastes must be earthquake-proof and leak proof. To date, a solution to this problem has not been found.

8. Another objection to nuclear power plants is thermal pollution; releasing too much heat into the environment. Nuclear power plants return heated water to nearby rivers or lakes. Sometimes the water is just a few degrees warmer than the surrounding body of water. This can cause severe environmental damage (e.g., algae blooms, increased oxygen demand by organisms in the water, fish-kills, etc.).

9. Discuss the benefits of a nuclear power plant.
    a) creates an enormous supply of heat energy
    b) produces plutonium which may also serve as a source of nuclear power
    c) furnishes a source of neutrons which can be used to produce radioactive isotopes employed in medicine.

Lesson 83 Energy Conservation

Aim: What can be done to conserve energy?

Objectives

To identify ways by which people can conserve energy
To discuss incentives and penalties that could be used to stimulate energy conservation awareness
To analyze the energy policies of New York City, New York State, and the Federal Government
To interpret energy issues in the news

Strategies

1. Elicit various methods of conserving energy. Suggestions should include:
   - a) greater use of mass transit
   - b) turning off lights and appliances when not in use
   - c) purchasing energy efficient appliances and machinery
   - d) using alternate energy sources

2. Discuss what might be done to encourage people to save energy. For example, should the government penalize high energy users and reward those who contribute to conservation? How might this be done? How practical is it?

3. Discuss the position of the government on energy conservation. What role does the Federal Office of Energy have in promoting energy conservation? How well has this been done? How could it be improved?

4. Discuss topical energy items in the news. What is the nature and implication of these events? How do these events effect the people in the area? the country?

Enrichment

1. What steps, if any, have you or your parents taken to conserve energy at home?
2. What problems might result if everyone is required to turn down his thermostat during the winter?

Lesson 84 Alternate Sources of Energy

Aim: Where will our energy for the future come from?

Objectives

To discuss the need for new and innovative means of obtaining energy
To describe future nuclear sources of energy, breeder reactors and nuclear fusion
To investigate other sources of energy from the earth: geothermal, oil shale, coal gasification, tidal power
To discuss the possibility of obtaining energy from orbiting solar collectors

Strategies

1. Discuss energy use. Indicate that the average person uses about 600 kilowatts of energy a mounth. Explain that on a large scale, the United States depends upon and uses more energy than any other nation. With only 1/17 of the world's population, our country uses about 1/3 of the world's energy. People have used more energy in the past 30 years than in all history before 1940. It is estimated that the world rate of energy use will quadruple by the year 2000.

2. Explain that we are increasing our need for energy, but our sources of fuel and electricity production are running out. They cannot keep up with demand. Elicit that petroleum and other fossil fuel reserves are being used up. Even the fuel for our present day nuclear reactors (U-235) is running out.

3. Challenge students to explain where energy for the future will come from. Discuss the following:
   a) Nuclear Energy
      Breeder Reactor: This reactor actually produces more fuel than it consumes. It does not use the rare U-235. Instead, it uses and converts the abundant U-238 into the usable fuel, plutonium. Explain that with the breeder reactor, uranium reserves can last for centuries rather than decades. State that this reactor is still in the experimental stage.
      Fusion Reactor: This reactor uses readily available isotopes of hydrogen (deuterium and tritium). Explain that this type of reactor has not yet been built. Scientists have not yet been able to produce and sustain a temperature high enough to cause a controlled fusion reaction to occur.

b) Energy From The Earth

Geothermal Energy: Explain that heat energy radiates constantly from deep in the earth's interior. Sometimes this energy becomes concentrated in localized areas near the earth's surface. When underground water comes into contact with naturally heated rock, steam is produced. By drilling into geothermally active areas, natural steam can be directed into the blades of turbines to produce relatively inexpensive energy. Only one plant is in operation in the United States today. This plant is expected to eventually provide enough energy to power the city of San Francisco.

Tidal Power: In certain areas, tides can rise as high as 12 meters or more. This is the case in Canada's Bay of Fundy, where the water surges up the sides of the bay. This is an untapped source of energy. Only one tidal power plant has been built so far. It is in France.

Coal Gasification: Pilot plants are presently under construction that will convert coal into a gas that can be used as a suppliment to natural gas.

Oil Shale: This type of rock contains a substance called kerogen, a hydrocarbon. When this is heated to very high temperatures, it releases vapors that are converted into raw shale oil. This can then be refined into petroleum products. A problem with the use of oil shale is that 1½ tons of rock must be used to produce one barrel of oil.

c) Non-Polluting Energy

Solar Energy: Some buildings already use solar energy. Blackened solar panels are placed on the roof where they are exposed to the maximum amount of sunlight. Pipes containing water are heated and provide hot water for the building.

Orbiting Solar Collectors: A satellite placed in orbit 36,000 km above the earth's equator can receive solar energy for 24 hours a day. This is about 6 times the solar energy collected in the best location in the United States. Energy could be transmitted to earth by microwaves.

4. Discuss the sources of our present energy supply. Most energy comes from fossil fuels (95%). Water power accounts for about 4%, and nuclear power about 1%.

UNIT VIII

POLLUTION OF THE ENVIRONMENT

Along with the blessings of modern technology, people are also paving the way to their own demise in the form of pollution. People have left their mark on the land, air, and waters of the earth; as well as on the health of all living things. The wastes of our own technology are slowly poisoning the biosphere.

In Unit VIII, students are given the opportunity to identify, observe, and measure the effects of pollutants on an ecosystem. These objectives are reached through an examination of a variety of pollutants as well as a study of topical pollution issues. Students come to realize that the effects on the environment are many in terms of health, recreation, economics, and aesthetics.

Students are encouraged to investigate new technologies, legislation, and individual action that can lead to a lasting solution to the pollution problem.

Lesson 85 Pollution

Aim: What is pollution?

Materials

jar of dirty water	jar of clean water
transistor radio	apparatus for generating NO_2

Preparation of Materials

Nitrogen dioxide may be prepared by placing 5 to 10 grams of copper turnings into 5 to 10 ml of concentrated nitric acid.

Objectives

To be able to define the term pollution
To identify specific kinds of pollution
To identify the source of major forms of pollution
To analyze the effects of pollution on the environment

Strategies

1. Display a jar of dirty water and a jar of clean water. Elicit which of the two samples the students would prefer to drink. Why? Use the reasons given by the students to construct a working definition of pollution. Consider such factors as:
   a) color
   b) odor
   c) presence of particles and/or other impurities

2. Discuss and develop the concept that pollution involves the addition of any substance or form of energy to the environment at a faster rate than the environment can handle or remove it.

3. Discuss the parts of the environment that may become polluted. Consider such factors as:
   a) water pollution from sewage and industrial wastes
   b) air pollution from smoke, exhaust chemicals, sprays, etc.
   c) solid waste or land pollution from refuse, litter, etc.

4. Elicit those activities which are the major factors responsible for the addition of pollutants to the environment.
   a) Transportation- 78 million tons
   b) Industry- 25 million tons
   c) Utilities- 15 million tons
   d) Heating- 12 million tons

5. Turn on the transistor radio. Play it on the greatest volume for several seconds. Elicit that not all pollution is physical, i.e., can be picked up and examined.

6. Incorporate the following into the original definition of pollution: Pollution is the unfavorable changing of our surroundings that are in large part due to the activities of people.

7. Generate a small amount of NO_2. Elicit the unpleasant odor. Discuss the effects of pollution in terms of daily events, e.g., dirty surfaces, irritating gases, loud and unpleasant noise, bad-tasting water, etc.

8. Define a pollutant as any substance that adversely affects a biotic or abiotic factor in the environment, provided that the substance is in sufficient concentration to produce a harmful effect.

Enrichment

1. List 4 common pollutants.
2. Identify the nature of a pollutant and the effects it has.

ADDITIONAL TEACHER NOTES

Lesson 86 The Atmosphere

Aim: What are the parts of the atmosphere?

Materials

chart showing layers of the atmosphere (reproduce for distribution)

Objectives

To understand why the atmosphere is needed
To be able to construct a model of the atmosphere
To understand the composition of the atmosphere
To understand the physical characteristics of the atmospheric layers

Strategies

1. Guide students to an understanding that the earth is surrounded by a blanket of air which is approximately 895 kilometers thick. Identify this as the atmosphere.

2. Challenge students to explain the importance of the atmosphere in terms of life on earth. Elicit that:
   a) Without air, the temperature on earth would be about 111°C during the day, and -150°C at night.
   b) The ozone layer of the atmosphere is needed for protection against the potentially lethal ultraviolet rays of the sun.
   c) The atmosphere contains oxygen which is needed for respiration.
   d) The atmosphere contains carbon dioxide needed by green plants for photosynthesis.

3. Challenge students to explain where the air surrounding the earth is most heavily concentrated. Elicit that air molecules are most heavily concentrated at the surface of the earth. Explain that this is due to the pull of gravity.

   Students should be able to conclude that as altitude (height above sea level) increases, the concentration of air molecules decreases.

   Explain that 95% of all life on earth is supported by an atmospheric layer less than 3.2 kilometers thick. At an altitude of 9.6 kilometers, humans cannot obtain enough oxygen. At an altitude of 19.2 kilometers, there is not enough air to support a burning candle.

4. Distribute the chart showing the layers of the atmosphere. Instruct students to examine the chart carefully.
   a) Elicit the layer that is closest to the surface of the earth. This is the troposphere. Explain that the troposphere is the lowest part of the atmosphere. State that temperature decreases with an increase in altitude. Ask why the temperature is highest near the surface of the earth. Explain that air is warmed near the earth's sufrace. Elicit that warm air rises and gradually cools. State that the troposphere is about 13 kilometers thick.

b) From the chart, elicit the layer located above the troposphere. The stratosphere is a stable layer with some upward and downward air movements. Explain that the stratosphere contains an ozone layer. This layer of gas filters out the intense ultraviolet rays of the sun. State that the stratosphere is about 19 kilometers thick.

c) Describe the mesosphere as the zone above the stratosphere. Explain that in the mesosphere, the air is very thin. State that the mesosphere is about 45 kilometers thick. Discuss the fact that 99% of the air is located in the bottom two layers below the mesosphere.

d) The uppermost layer of the atmosphere is the ionosphere. Explain that the ionosphere absorbs gamma rays and X-rays from the sun. Discuss its importance in sending radio waves.

5. List the gases of which air is composed at sea level.

Composition of Air

Gas	Percent by Volume
nitrogen (N_2)	78%
oxygen (O_2)	21%
argon (Ar)	0.94%
carbon dioxide (CO_2)	0.03%
helium (He)	0.01%
neon (Ne)	0.01%
xenon (Xe)	0.01%
krypton (Kr)	0.01%
methane (CH_4)	trace
ammonia (NH_3)	trace
hydrogen sulfide (H_2S)	trace
carbon monoxide (CO)	trace
nitrous oxide (N_2O)	trace

6. Elicit that nitrogen and oxygen make up the largest volume of gases in the air. Nitrogen accounts for approximately 78% by volume, oxygen about 21%.

7. Explain that the amount of water vapor in the atmosphere ranges from about 0.01% to about 4% by volume. Challenge students to account for the differences. Elicit that location is an important factor. Deserts, forests, or oceans affect the concentration of water vapor in the air. Explain that humidity varies from day to day and that temperature affects the ability of the air to hold water.

8. Gases which occur in amounts large enough to measure (including the inert gases) are present in relatively constant amounts over the surface of the earth.

9. Explain that the concentration of methane, ammonia, hydrogen sulfide, and nitrous oxide vary according to location. Ask which gases would be found in high concentrations over swamp areas. Elicit methane, ammonia, and hydrogen sulfide. What areas would have a high concentration of nitrous oxides which are pollutants? Explain that high readings can be found over industrial areas.

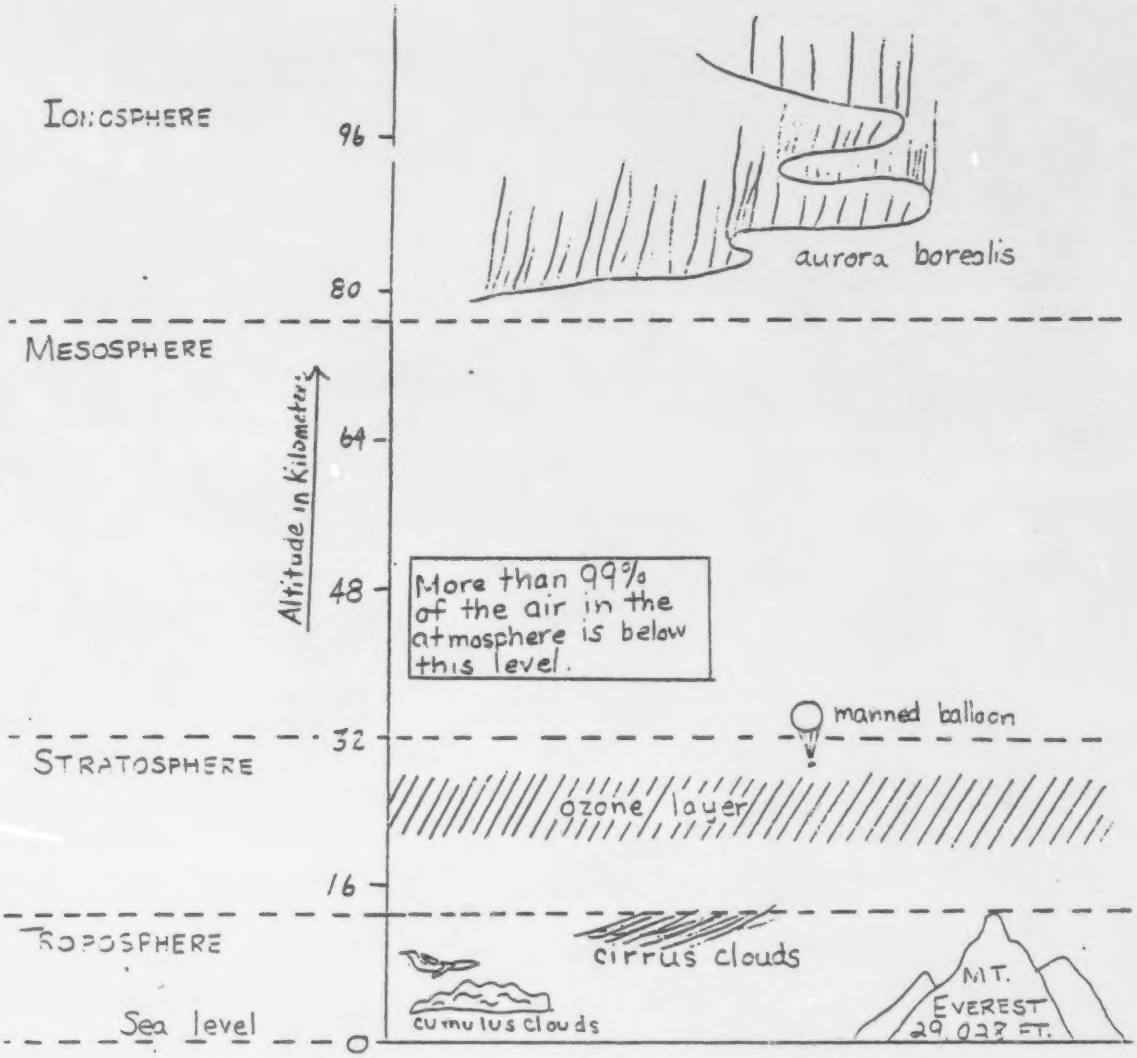
10. Ask why it is necessary to specify that the chart lists the composition of the atmosphere at sea level. Explain that gravity has an effect on the air molecules. Large and heavy air molecules are pulled down very easily; thus these are not found in such high concentrations at high altitudes.

Enrichment

Discuss the changes in temperature associated with a rise in altitude through each layer of the atmosphere.

ADDITIONAL TEACHER NOTES

Layers of the Atmosphere


IONOSPHERE
96
80
aurora borealis
MESOSPHERE
Altitude in Kilometers
64
48
More than 99% of the air in the atmosphere is below this level.
32
manned balloon
STRATOSPHERE
ozone layer
16
TROPOSPHERE
cirrus clouds
MT. EVEREST 29,028 FT.
cumulus clouds
Sea level
0

Lesson 87 Atmospheric Conditions

Aim: What are some weather factors?

Materials

weather maps, enclosed terrarium, thermometer

Objectives

To be able to explain the factors involved with weather
To understand the forces that keep the earth warm
To understand the factors that cause the winds
To identify and differentiate the different forms of precipitation

Strategies

1. Distribute weather maps (reproduced) from a local newspaper. Help students identify and understand the symbols used.

2. Ask students to describe the weather. Include such factors as sunlight, temperature, wind speed and direction, and precipitation.

3. Construct a definition of weather. Define weather as the conditions of the atmosphere at a given time and place.

4. Discuss how the earth is warmed.
   a) The Sun- Explain that the earth receives approximately two billionths of the energy radiated by the sun. Of this, approximately one third is reflected back into space.
   b) The Greenhouse Effect- Radiation, or energy from the sun, travels in the form of electromagnetic waves. This radiant energy is absorbed by the earth and trapped by the atmosphere. This is similar to what happens in a greenhouse; short wavelengths of light pass through the glass window. This light energy is absorbed and reradiated as long wavelengths of heat energy. The longer rays cannot pass back out through the glass easily, and so are trapped inside. In the atmosphere, carbon dioxide and water vapor serve the same function as the glass in a greenhouse.

   Exhibit the greenhouse effect for students by placing an enclosed terrarium and thermometer in full sunlight. Compare it to the temperature in the room.

5. Explain how winds are caused. Discuss the fact that unequal heating of the earth causes differences in temperature. These temperature differences are responsible for differences in air pressure. Air pressure differences cause the movements of large masses of air; or wind.

   Elicit what happens when you open a window on a cold day. Cold air from outside rushes inside. Cold air is usually of higher pressure than warm air. Air flows from areas of high pressure to areas of low pressure, causing winds. (illustrate this with weather maps.)

Discuss the rotation of the earth on its axis. Explain that the direction of air movements change as the earth spins on its axis. Discuss the Coriolis Effect. Explain that moving air is turned to the right, north of the equator, and to the left, south of the equator.

The earth spins on its axis from west to east. As it spins, it carries the atmosphere with it. At the equator, the speed of the earth's rotation is about 1,600 kilometers per hour. As you move toward the poles, the speed decreases.

An air mass moving from the equator toward the poles maintains a constant speed (due to inertia). However, as you approach the poles, the surface speed of the earth decreases. The air mass now appears to be moving ahead of the surface. In other words, it is deflected to the right.

6. Elicit what results when air can no longer hold moisture. Explain that precipitation consists of drops of water that fall from the atmosphere.

Discuss the forms of precipitation. Include rain, snow, sleet, and hail.

Discuss the formation of precipitation. Explain that in order for precipitation to form, small particles (such as dust, ash, pollen, or bacteria) are needed to act as nuclei. Water molecules condense (change from gas to liquid) around these nuclei and form tiny water droplets.

Explain that warm air holds more water vapor than cold air. What happens to warm air? It rises and cools. As it cools, it can hold less water vapor. The water vapor condenses and falls to earth as some form of precipitation.

Enrichment

1. Explain how barometric readings are used to forecast weather changes.
2. Discuss the wind belts of the earth and why they are formed.

Lesson 88

Air Inversions- Lab Activity

Aim: How are thermal inversions produced?

Materials

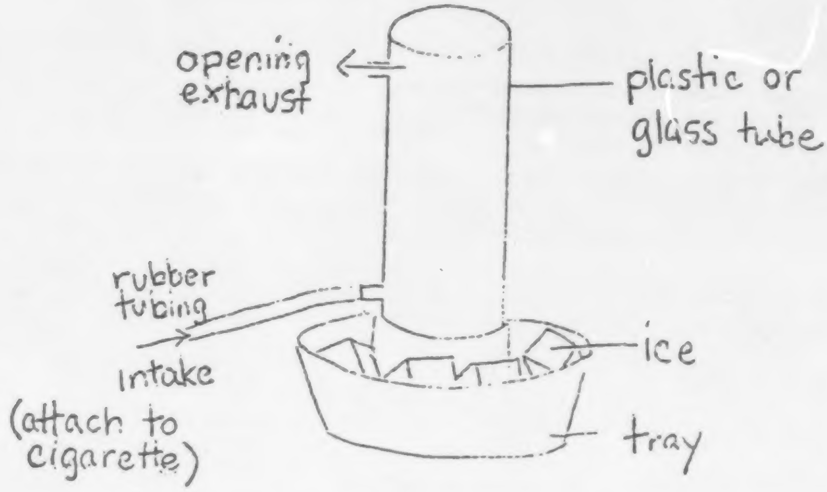
class set of thermal inversion tubes and set-ups, 2 thermometers for each tube, 1 cigarette for each tube, matches, ice cubes, hot water

Objectives

To demonstrate the formation of a thermal inversion
To demonstrate the lack of atmospheric movement during an inversion
To demonstrate how an inversion is broken

Strategies

1. Demonstrate the proper technique for use of the inversion chambers. See following diagram for setting up.


opening exhaust
plastic or glass tube
rubber tubing
intake
(attach to cigarette)
ice
tray

2. Permit students to work in small groups.

3. This laboratory activity can be adapted and given as a demonstration lesson.

STUDENT LABORATORY WORKSHEET

Lesson 88 How are thermal inversions produced?

Name ______________________________ Date ____________ Section ______________

Introduction

When air is heated, it becomes lighter and more buoyant that the air surrounding it. This is the scientific principle used in large balloons. A burner heats the air inside the balloon, making it possible for the balloon to rise and drift with the wind. When the balloonist removes the burner and allows the air inside the balloon to cool, it will start to descend.

A similar situation occurs frequently over cities. Under a high pressure center with calm wind and clear sky, the air near the surface of the earth is heated and rises upward; air that is cooled on hills or mountain slopes becomes heavier and slides downward to the lowest level it can find. A layer of warm air is now located over a layer of cool air. Warm, smoky air from home furnaces, industry, or automobiles will rise as long as it is warmer than the surrounding air. When it reaches the layer of air above it that is warmer, the polluted air stops rising. This upper layer of warmer air is known as a thermal or temperature inversion layer. Smoke, gases, and pollutants form smog and begin to collect under the inversion layer which is acting like a lid on the area. This condition occasionally lasts for many days, creating dangerous health conditions. To break up an inversion of this kind there is usually a great change in the weather: precipitation, strong winds, the arrival of cooler air, or intensified heating by the sun.

Materials

thermal inversion tube and set-up, 1 cigarette, matches, ice cubes, hot water, two thermometers

Procedure

1. Suspend a thermometer about 8 centimeters above the top of the chamber.

2. Suspend a second thermometer so that it reaches the bottom of the chamber. Record the temperatures of the two thermometers in Table 1.

3. Fill the tray with ice. Observe the thermometers until the top is about 5° warmer than the bottom. Record these temperatures.

4. Quickly insert a cigarette into the holder. Attach the outer end to the chamber base. Light the cigarette and squeeze the bulb at the same time. STOP squeezing the bulb when the smoke is about 15 cm from the top of the chamber.

5. Carefully drain the ice water from the tray.

6. Slowly and carefully add hot water to the tray. Record the temperatures as soon as you have finished adding the hot water.

7. Observe the level of the smoke. When the inversion breaks (the smoke begins to leave the chamber), record the temperature of the two thermometers.

Post Lab Questions

1. Which weather condition necessary for the break up of an inversion was simulated in the inversion chamber?
2. What other methods might you have used to break the inversion?
3. What effects might an inversion have on a large industrial city?
4. Which procedure in the experiment produced the inversion.?

STUDENT DATA SHEET

Lesson 88 How are thermal inversions produced?

Name ______________________ Date ____________ Section ____________

Table 1. Temperature Changes During Inversion

Temperature	Thermometer Reading °C	
	Top	Bottom
Start		
After adding ice		
After adding hot water		
When inversion broke		

Lesson 89 Sources of Air Pollution

Aim: How is air pollution produced?

Materials

sand paper, wood block, Oil of Wintergreen

Objectives

To understand how air pollutants are produced
To be able to recognize different industries in the community as possible sources of pollution
To describe the chemical reactions that take place between pollutants and the atmosphere

Strategies

1. Conduct a general class discussion on air pollution. Define air pollution as the addition of any substance to the air that is harmful to living things and their surroundings.

2. Elicit how air pollutants are produced. Discuss the fact that air pollution occurs as a result of three basic factors: surface friction, vaporization, and combustion.
   a) Surface Friction- Define friction as the resistance which results when one object is rubbed against another. Explain that during this process, small pieces of matter are freed and become suspended in the air. These small pieces of matter are referred to as particulate pollution. Demonstrate the formation of particulate pollution with a piece of sandpaper and wood block. Use a flashlight to show the fine, suspended particles. Elicit where and how this type of pollutant might be produced. Discuss construction sites, sawing mills, drilling sites, and the grinding of asphalt, steel, and lumber.
   b) Vaporization (Evaporation)- Describe vaporization as the physical change of a substance into a gaseous state. Demonstrate evaporation using an aromatic organic compound such as Oil of Wintergreen. Elicit the sources of such pollutants. Include [illegible]-drying paints, glues, etc.
   c) Combustion (burning)- is the rapid chemical union of a substance with oxygen. Discuss the fact that complete combustion yields carbon dioxide and water vapor. Explain that not all combustion is complete, due to insufficient air or fuel. Tell the students that incomplete combustion produces soot (unburned particles), carbon dioxide, carbon monoxide, water vapor, and hydrocarbons.

Explain that many fuels are not pure. They contain such contaminants as compounds of nitrogen and sulfur. Upon burning, these fuels produce nitrogen oxides and sulfur dioxide. Other pollutants produced by the burning of impure fuels include ozone, lead, and fluorides.

3. Explain that some air pollutants are not directly produced by human activities. They are due to synergistic reactions; pollutants already in the environment react to form additional pollutants. Examples are:
   a) smoke + fog → smog
   b) formation of acid mists

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

sulfur + water → sulfurous acid
dioxide

or

$$SO_2 + H_2O \longrightarrow H_2SO_4$$

sulfur
dioxide + water → sulfuric acid

and

$$NO_2 + H_2O \text{ (vapor)} \longrightarrow HNO_3$$

nitrous + water → nitric acid
oxide   vapor

Explain that these acids will corrode such exposed surfaces as metal, brick, stonework, and granite.

   c) photochemical smog-produced by the effects of light on chemicals in the air. As traffic conditions and sunlight increase during the day, city air becomes a yellow-brown haze with a characteristic odor.
   d) Freon, or fluorocarbons from aerosol cans are believed to be breaking down the ozone layer of the upper atmosphere.

4. Challenge students to compile a list of sources of air pollution.

Industry	Motor Vehicles	Natural Sources
power plants	gasoline	forest fires (lightning)
oil refineries	other emissions	volcanoes
metal refineries		meteors
chemical plants	Burning	windswept desert areas
paper mills	furnaces	
	incinerators	

Enrichment

Since 1969, the New York City Department of Air Resources has produced a Daily Air Pollution Index. It describes pollution levels in the City during the 24 hours preceding the report (from 3 P.M. the previous day to 3 P.M. the current day). They describe the air quality as follows:
   a) Good- levels for the day were at or below the federal standard.
   b) Acceptable- although the federal standard was not met, the levels are not so high as to jeopardize the meeting of that standard over the course of the year.

c) Unsatisfactory- if these levels were to occur over a substantial number of days, the standard would not be met.
d) Unhealthy- refers to chromic, not short-term exposure to levels above the federal standards.

A Study of the Air Pollution Index for New York City

(Data represents the number of days for a given year.)

Pollution Level	1969	1970	1971	1972	1973	1974	1975	1976
Good	0	0	61	58	48	108	107	151
Acceptable	38	86	198	252	229	193	204	121
Unsatisfactory	209	196	80	48	65	27	23	49
Unhealthy	114	79	26	7	23	36	19	45

Discuss the following:

1. What changes have occurred in the air quality of New York City over the past 8 years?
2. What possible reasons are there for these changes?
3. What can cause "unsatisfactory" and "unhealthy" conditions in New York City?
4. Until recent years, sulfur dioxide was a major pollutant in New York City. Why has this changed? (The city has placed restrictions on the sulfur content of fuels that may be burned in the city.)

Lesson 90 The Generation of Air Pollutants

Aim: What is the chemistry of air pollution?

Materials

NOTE: refer to listing of materials for that particular strategy.

Objectives

To demonstrate the production of various air pollutants- particulates, sulfur dioxide, nitrogen oxide, ozone

To understand the chemical reactions involved in the production of air pollutants

Strategies

1. Generation of Soot

   Materials: alcohol, kerosene or toluene, bunsen burner, candle, 3 crucibles, 4 glass plates, safety matches, tongs

   a) Place a small amount of each of the combustible liquids into separate crucibles.
   b) Ignite each of the materials including the bunsen burner flame.
   c) Collect any carbon particles which may form from the burning on a glass plate, held over each crucible.

2. Review differences between complete and incomplete combustion:

   Complete combustion: $C + O_2 \longrightarrow CO_2$

   Incomplete combustion: $2C + O_2 \longrightarrow 2CO$ and unburned carbon particles

   Indicate the colors of the flames of different burning materials; yellow flames are cooler than blue flames. Most soot is produced in cooler flames because not all the carbon is combined with oxygen.

3. Generation of Sulfur Dioxide

   Materials: sulfur powder, deflagrating spoon, blue litmus paper, water, bunsen burner

   NOTE: THE FOLLOWING PRECEDURE SHOULD BE PERFORMED IN A HOOD!

   a) Place a small amount of sulfur in a deflagrating spoon.
   b) Heat the sulfur in a bunsen flame.
   c) When the sulfur ignites, remove it from the flame.
   d) Have a student use tongs to hold a piece of wet, blue litmus paper 10 to 15 cm above the burning sulfur.

4. When sulfur is burned in the air, it combines with oxygen to form SO_2 (sulfur dioxide). The same reaction occurs when a high sulfur coal or fuel oil is burned in a furnace. When sulfur dioxide reacts with rain, moisture in the air, or any moist surface (like your eyes), it will form sulfurous or sulfuric acid:

$$SO_2 + H_2O \longrightarrow H_2SO_3 \qquad \text{(sulfurous acid)}$$

$$SO_2 + H_2O \longrightarrow H_2SO_4 \qquad \text{(sulfuric acid)}$$

5. Generation of Nitrogen Dioxide
   Materials: test tube, copper turnings, dilute nitric acid, blue litmus paper, water, test tube rack

   a) Place 5 to 10 grams of copper turnings in a test tube.
   b) Fill to one-third full with dilute nitric acid.
   c) When the yellow-brown fumes of NO_2 (nitrogen dioxide) are generated, place a wet piece of blue litmus paper over the top of the test tube.

6. Nitrogen dioxide is a gas that combines with moisture to form an acid similar to sulfur dioxide. Nitrogen dioxide as well as other forms of nitrogen oxides are formed when nitrogen impurities found in fossil fuels are burned at high temperatures. The yellow-brown nitrogen dioxide is a component of the smog found over New York City.

ADDITIONAL TEACHER NOTES

Lesson 91 Measurement of Particulate Matter- Lab Activity

Aim: How can we measure particulate air pollutants?

Materials (for each team)

microscope, ruler, wax marking pencil, petroleum jelly, plastic microscope slide, cover slip, tape, small box

Objectives

To collect samples of particulate matter on prepared slides
To observe and analyze the various forms of particulate matter

Strategies

1. Demonstrate how slides are to be prepared and have students prepare a slide in class.
2. Explain the parts of the laboratory exercise to be completed at home. Emphasize the importance of not smearing the petroleum jelly-coated slides after the particle collection has been completed.
3. Encourage students to complete their observations in class on the following day.

Enrichment

At the completion of the lab, compare the rate of fall of particulate matter in different neighborhoods around the school

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 91 How can we measure particulate air pollutants?

Name ______________________ Date ______________ Section ____________

Introduction

Air pollutants can be solid particles, liquid droplets, or gas. Both solid and liquid air pollutants are known as particulates. This type of pollution can be seen when a ray of light shines through a window. Most of the particulates that fall are very tiny- from 1/100,000 to 1/2 the size of the period at the end of this sentence. Tons of these particles fall over a city, such as New York, every day. There are several types of particulates.

a) Dust- Dust is composed of irregularly shaped, almost microscopic particles. Most of the dust in the atmosphere comes from volcanoes and meteors that have burned in the earth's atmosphere. Inside buildings, most of the dust is in the form of fibers from rugs, draperies, furniture, or clothing.

b) Soot or fly ash- This material is found where combustion occurs. An incinerator, furnace, or poorly tuned automobile engine produces large quantities of soot or fly ash. These particles are round and smooth and are composed of carbon.

c) Pollen- Produced by flowers for reproduction, pollen is produced in great amounts in the spring and fall of the year. The form of a pollen grain is usually symmetrical, but there are as many different shapes as there are kinds of flowers.

d) Friction particles- Rubber particles are produced from tires as they spin along the road. Metal particles are formed from the nickel and steel from the inside of automobile engines; lead particles are from gasoline.

e) Aerosols- Particles of solids or liquids that are small enough to remain suspended in the atmosphere are known as aerosols.

Materials

wax marking pencil, plastic slide, petroleum jelly, tape, small box, cover slip, microscope, ruler

Procedure

1. Use a wax marking pencil. Mark off an area on the slide that measures about one square inch (1 inch high x 1 inch wide).

2. At home, cover the slide with a thin, even layer of petroleum jelly.

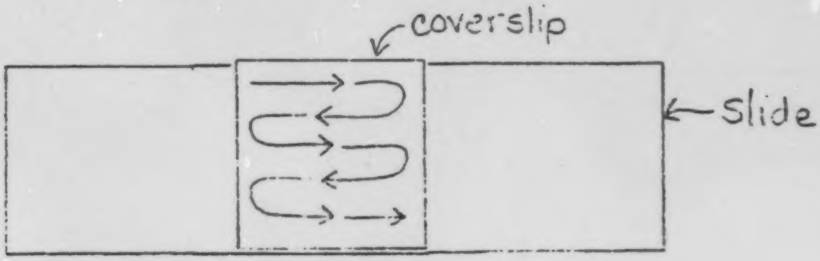
3. Place your slide on a windowsill. Leave it exposed until the next day.

4. Fill in items 1, 2, and 3 on the data sheet.

5. Carefully tape the slide at its edges to the bottom of a small box. Be careful not to disturb the layer of petroleum jelly in the marked area of the slide. Bring the slide to class.

6. Add a coverslip to the slide. Examine you slide under the microscope. Try to identify some of the particles as described in the introduction to this lab. Enter these observations in item 4 on the data sheet.

7. Count the number of particles inside the marked area of your slide. Scan the slide as illustrated.



Enter the number of particles you counted in item 5.

8. Complete the calculations to determine the rate of fall for particulate pollution in your test area.

Post Lab Questions

1. According to your results, what is the main source of particulate pollution in your test area?
2. Is there any particulate pollution in areas where people do not live? Explain.
3. How could particulates damage plants and animals?

STUDENT DATA SHEET

Lesson 91 How can we measure particulate air pollution?

Name ______________________ Date __________ Section ____________

Observations

1. Date of observation ____________

2. Test area (street location) ____________________________________

3. Number of hours slide was exposed ___________

4. Particulate Identification

Type of Particulate	Number
dust	_____
fly ash or soot	_____
pollen	_____
friction particles	_____

5. Most common type of particulate? ________________________________

6. Particles in 1 sq. in. x 144 = ________________________________
number of particles that fell on 1 sq. ft.

7. Divide: $\frac{\text{Number of particles per square foot}}{\text{Number of hours slide was exposed}}$ =

This final figure is the rate of fall in your test area.

Lesson 92 Measurement of Gaseous Pollutants- Lab Activity

Aim: How can we measure the acid content of the air?

Materials

funnel, 1-hole rubber stopper, side-arm Erlenmeyer flask, distilled water, rubber tubing, vacuum source, ring stand assembly, buret, buret clamp, neutral red indicator, 0.01 M NaOH solution

Objectives

To sample the air for gaseous pollutants
To measure the total acid content of the air
To interpret the results and relate them to environmental conditions

Strategies

1. Set up the pump and collecting apparatus well in advance of class. It may be advisable to set it up the day before.

2. Review with the class the proper technique for titrating a sample of an unknown pH.

3. The sample can be collected in a large flask and divided into smaller portions for each student group.

4. A pH of 5.7 is average for rainwater. This is due to the presence of CO_2 which forms carbonic acid. Neutral red will change color at a pH of approximately 6.8 to 8.0. Red indicates an acid, yellow indicates a base.

STUDENT LABORATORY WORKSHEET

Lesson 92 How can we measure the acid content of the air?

Name ______________________ Date ______________ Section __________

Introduction

The production of nitrous oxides and sulfur dioxide during daily activities has had profound effects on the total environment- on buildings, people, plants, and other organisms.

Much of the damage of air pollution is due to acid mists. These aerosol suspensions are formed directly by people. Sulfur dioxide and nitrous oxides react with the natural moisture in the air. This is known as a synergistic reaction, the reaction of two substances that will produce a new substance that is far worse than either of the original substances. Sulfurous acid, sulfuric acid, and nitric acid are produced in the form of a fine aerosol mist.

What effects do these acids have? In Europe and parts of the northeastern United States, the pH of the rainfall has dropped from about 5.7 to 3. The acid rainfall has its effects on building materials. In some cities, statues of marble and sandstone have completely lost their features. The raindrops burn holes in the broad leaves of certain sensitive plants. What effects does this acid mist have on us as we inhale, and it comes into contact with the delicate moist tissues of our respiratory system?

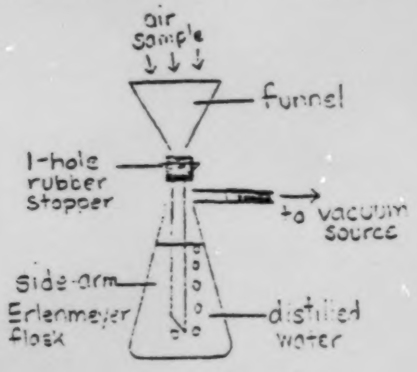
In this exercise, you will be testing the air around your school to measure its acid content. A large volume of air must be sampled because the acid droplets in the air are so small.

Materials

funnel, 1-hole rubber stopper, side-arm Erlenmeyer flask, distilled water, rubber tubing, vacuum source, ring stand assembly, buret, buret clamp, neutrao red indicator, 0.01 M NaOH solution

Procedure

1. Assemble the collection apparatus as shown, or obtain a sample that has been collected by this method from your teacher.

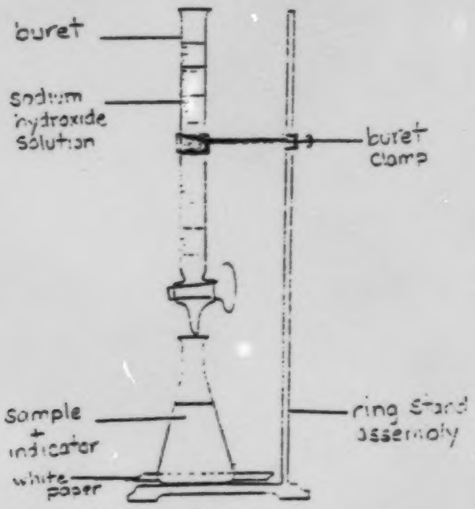


2. Attach the apparatus to a vacuum pump. Record the rate and the total sampling time on the data sheet.

3. When the sampling is completed, rinse any particles on the funnel into the flask with a small amount of distilled water. Remove the collection apparatus from the flask.

4. The concentration of acid in the flask can be determined by the addition of a known amount of base. You will add enough base to the acid to neutralize it, or make it the same pH as water. In order to find the neutral point, you must use an indicator. This is a substance that changes color when the pH is changed. Add 3 drops of the indicator, neutral red to the flask.

5. Fill a buret with a solution of base (0.01 M sodium hydroxide). Record the exact amount of solution in the buret before you start.



6. Place the flask under the buret on a piece of white paper. This will help you see a color change more easily.

7. Gently swirl the flask after the addition of sodium hydroxide in a dropwise fashion. As more sodium hydroxide is added, the red color will fade away to yellow. The end point of the titration is reached when the addition of a single drop of sodium hydroxide solution produces a permanent, faint yellow color throughout the solution.

8. Record the volume of sodium hydroxide in the buret when you are finished.

Post Lab Questions

1. What are the major sources of acid pollutants in your school area?
2. What effects of acid pollution have you seen in your own neighborhood?

STUDENT DATA SHEET

Lesson 92 How can we measure the acid content of the air?

Name ______________________________ Date ____________ Section ____________

Observations

1. Collection Data

   a) Rate of collection __________

   b) Total sampling time __________

2. Sodium hydroxide data

   a) Volume before starting __________

   b) Volume when finished __________

   c) Volume used __________

3. Calculations

   a) volume of sodium hydroxide ______ $\times \frac{0.01}{1{,}000}$ = moles of acid in sample solution

   Mole: The amount of a substance in grams, equal to the molecular weight of that substance.

   b) Concentration of acid = $\frac{\text{moles of acid}}{\text{volume of air sampled}}$

Lesson 93 The Effects of Air Pollution

Aim: What are the effects of air pollution?

Materials

sulfuric acid, marble chips, beaker, picture of lungs of smoker and non-smoker

Objectives

To be able to identify the many human diseases and disabilities related to air pollutants
To understand how air pollution can affect vegetation
To identify the effect of air pollutants on buildings and statues
To appreciate the high "cost" of air pollution

Strategies

1. Elicit that all living things are affected by the air pollution produced as a result of human technology.

2. Discuss the effects of particulates. Explain that in a large city, each breath brings approximately 70,000 small particles into the lungs. In contrast, country air contains about 40,000 particles per breath. Elicit those body defenses which serve to clean or filter the air we breathe. Explain that hairs in the nose and the mucus linings of the nose and throat trap many of the larger particles; smaller particles enter the lungs. Because of this, city dwellers have blackened lung tissue. Scientists estimate that a non-smoking New Yorker breathes air which is equivalent to smoking two packs of cigarettes per day.

   Elicit the effects of such particulates as dust and pollen.

3. Discuss sulfur dioxide (SO_2) and its affects on individuals. Explain that a concentration of 6 parts per million (ppm) paralyzes and corrodes respiratory organs. A study in New York City showed that the death rate starts to increase when the concentration of sulfur dioxide reaches a level of 0.20 ppm. Hospital admissions for children (under 16) suffering from asthma rises from 34.2/100,000 individuals to 50.7/100,000 individuals during times of high air pollution.

   Elicit what happens when sulfur dioxide comes into direct contact with water. An acid forms. Explain that the surface area of the lungs is about 25 times greater than the surface area of the exposed skin surface; and every square inch of the lungs provides water.

   Explain that the acids formed in the atmosphere fall with the rain and kill crop plants (wheat, barley, oats, white pine, cotton, alfalfa, etc.). A power plant in Kingston, Tennessee has killed all the white pine within a radius of 100 miles. Over 50 years ago, two copper smelters in another part of Tennessee released enough airborne sulfur to poison the soil. There is no vegetation there even today.

4. Discuss the effects of carbon monoxide (CO) poisoning. Elicit that a one hour exposure of 120 ppm can impair driving ability. 100 ppm have been measured in tunnels and parking garages. In traffic jams, 400 ppm have been measured. Smokers have 5% of their hemoglobin permanently combined with carbon monoxide.

5. Explain that nitric oxide (NO) reduces the oxygen carrying ability of the blood. Nitrogen dioxide (NO_2) combines with water to form nitric acid (HNO_3). Elicit the effects of these on the eyes, nose, bronchial tubes, and lungs. Exposure to NO_2 results in irritation and inflamation of delicate, moist membranes and tissues.

6. During industrial and technological processes, many different hydrocarbons are produced. Some are carcinogenic, i.e., they can cause cancer.

7. Discuss ozone (O_3). Ozone corrodes rubber. It is also harmful to the upper surface of green plant leaves, causing spotting.

8. Fluorides, especially hydrogen fluoride gas (HF) accumulates in the leaves of plants. The leaf body remains uneffected while lethal amounts of the fluoride concentrate in the leaves' edges. Animals feeding on these plants develop the disease fluorosis. Fluorosis affects the teeth and joints of animals.

9. Elicit some human diseases associated with air pollution.
    - a) allergic disorders
    - b) acute upper respiratory infections
    - c) emphysema
    - d) bronchitis
    - e) heart disease
    - f) circulatory diseases
    - g) respiratory diseases

10. Discuss the effects of air pollutants on non-living things. For example, metals corrode faster in a city environment than in a rural environment. Copper and aluminum corrode 5 times faster. Iron corrodes 6 times as fast, brass 8 times, zinc 15 times, nickel 25 times, and steel 30 times.

    In New York City, stone such as marble and sandstone are affected. Demonstrate the effects of sulfuric acid on marble chips.

    Nitrogen oxides and ozone destroy paint, weaken fabrics, and dry out rubber.

Enrichment

1. Discuss air pollution hazards associated with various occupations; (coal mining, asbestos manufacture, etc.).
2. How are air pollution episodes related to heart attack and death rate?

Lesson 94 Possible Solutions to the Air Pollution Problem

Aim: What practical solutions are there to the problem of air pollution?

Materials

thistle tube, 3 collecting bottles, 3-2 hole rubber stoppers, glass tubing, blue litmus paper, electrostatic precipitator (if available), water, sodium sulfite, dilute sulfuric acid

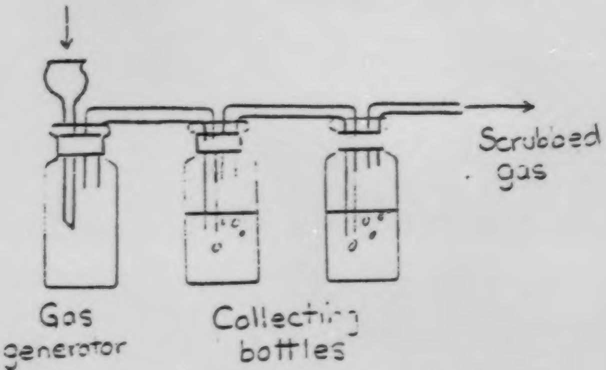
Objectives

To demonstrate the use of scrubbers and precipitators in eliminating air pollutants
To discuss the nature of the Clean Air Act
To formulate practical solutions to the air pollution problem

Strategies

1. Discuss the automobile as a source of air pollution. Explain that pollution from transportation accounts for about 42% of all air pollution. Automobiles are the single most dangerous source of air pollution. Challenge students to suggest how automobile pollution might be reduced. Include:
    a) Walk when you can. Use buses and trains. Ride a bike.
    b) Urge your family to buy gasoline with the least amount of lead and the lowest octane level the family car can take.
    c) Suggest that the pollution controls on the family car can be checked to see if they are doing their job. The engine also needs regular tuning.
    d) Turn the motor off when parked, even if it is only for a few minutes.
    e) Work with others for a good public transit system.
    f) Urge the development of cars that won't pollute.

2. Explain that harmful gases may be removed from exhaust fumes by means of an air pollution control device such as a scrubber. The scrubber can remove any chemicals that can be dissolved in water. Set up a model scrubber as shown.



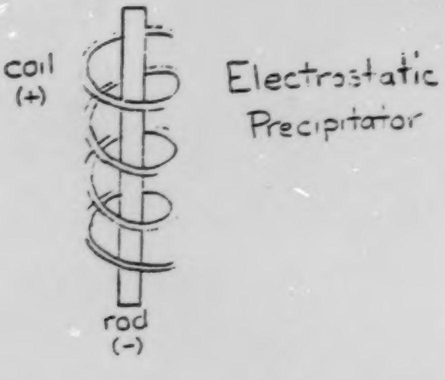
This model scrubber is designed to remove sulfur dioxide from the air. The gas that will be produced in the generator bottle is SO_2 which will then bubble through the water in the collecting bottle chain.

3. Demonstrate the scrubber.
   a) Fill the bottom of the gas generator bottle to a height of about $\frac{1}{2}$ cm with sodium sulfite.
   b) Add a small amount (no more than 10 ml) of sulfuric acid through the thistle tube.
   c) Allow the gas produced to bubble through the set-up for a few seconds.
   d) Test the gas that comes out of the last bottle in the chain with moist blue litmus paper.
   e) Test the water in each of the bottles with blue litmus paper.

The gas coming out of the last collecting bottle should give no (or only a slight) acid reaction with the litmus paper. The water in the first two collecting bottles should give a strong positive reaction showing the formation of sulfuric acid in the collecting bottles.

4. Explain that power plants that produce energy by burning coal and oil also produce pollutants (about 20% of the total). Challenge students to suggest how power plant pollution may be reduced. Suggestions might include the following:
   a) Turn off the lights, radio, and TV when no one is using them.
   b) Run the dishwasher only when it is full.
   c) Use the air conditioner only when someone is home and only when it is very hot.
   d) Dry your clothes outside when possible, instead of using the dryer.
   e) Work for adequate pollution control equipment on polluting power plants.

5. What kinds of air pollution control devices can be used on coal and oil burning power plants? A scrubber can be used to remove any chemicals that can be dissolved in water. An electrostatic precipitator is used to remove particulate matter from smoke.



In this device, smoke is passed along a coil of wire that has a positive electrical charge; this, in turn, causes a charge to be built up on the smoke particles. In the center of the coil (or just above the coil) is a negatively charged rod. The positively charged particles in the smoke are attracted to the rod where they can be collected in bags or containers. Demonstrate the electrostatic precipitator if available.

6. Waste disposal and burning refuse are responsible for about 5% of the total air pollution. Challenge students to suggest how this type of pollution may be reduced. Suggestions might include the following:
   a) Don't burn leaves or trash.
   b) Buy packaged foods and liquids in returnable containers, if possible.
   c) If you live in an apartment house with an incinerator, observe the regulations for its use and see that it is pollution-controlled.
   d) Reuse and recycle whatever you can.
   e) Work for sanitary landfill disposal, or the installation of modern municipal incinerators that can produce heat and electricity instead of pollution.

7. Heating buildings contributes to the pollution problem. Challenge students to suggest methods of reducing this type of pollution and suggest ways to conserve irreplaceable fuel. Suggestions might include:
   a) Keep the windows closed when the heat is on.
   b) Set the thermostat at 68° or 70°, and wear a sweater if you are cold.
   c) Turn the heat down at night or when you are away for more than a couple of hours.
   d) Work for pollution controlled heating, where possible.

8. What has the Federal Government done to help ensure clean air for all of us? The Clean Air Act was passed by Congress for the following purposes:
   a) Air pollution prevention and control through research, technical and financial assistance to State and local governments, and to assist in the development and operation of regional air pollution control programs.
   b) Establishment of emission standards for moving sources: motor vehicles, aircraft, etc.

Enrichment

To meet the stricter automobile exhaust limits that went into effect for 1975 automobiles, U.S. manufacturers are using a catalytic converter system. Discuss the pros and cons of such a mechanism. Also, investigate the chemistry of the converter.

Lesson 95 Sounds vs. Noise

Aim: What is the difference between sound and noise?

Materials

tuning fork, 600 ml beaker, tape recording or record of various loud, annoying noises, slinky

Objectives

To understand what causes sounds to be produced
To be able to describe the differences between sounds
To distinguish the factors that separate sound from noise

Strategies

1. Strike a tuning fork. Elicit that a sound is produced. Elicit also that the ends of the tuning fork are moving.

2. Strike the tuning fork again; this time with a greater force. Place the ends of the tuning fork into a beaker of water. What happens? Why?

3. Sound is produced by a vibrating object. A vibration is a rapid back and forth movement.

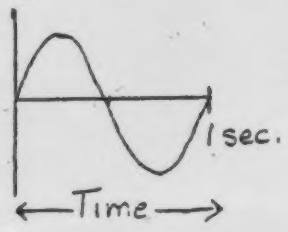
4. Elicit the vibrating parts in a: drum, guitar, transistor radio, human voice.

5. Challenge students to discuss vibrations we cannot hear. An example is a dog whistle. Explain that the range of human hearing is from 20 to 20,000 vibrations per second. Have students explain why humans cannot hear a dog whistle.

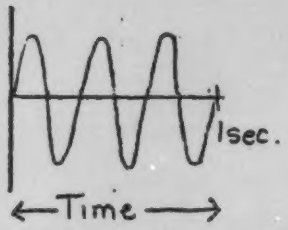
6. Strike 2 tuning forks of different frequencies. Elicit the differences in sounds produced. Elicit that high-pitched tuning forks have a greater number of vibrations per second than do lower-pitched tuning forks.

7. We can represent sound using the following diagrams.

Each complete up and down wavy line is one complete vibration. The diagram represents 1 vibration per second (1 hertz).



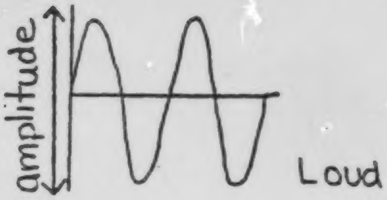
This diagram represents a time of one second, but there are 3 vibrations per second (3 hertz).

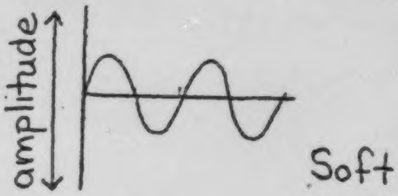


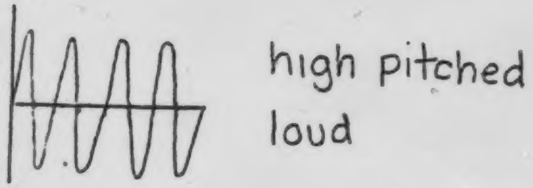
8. Strike a tuning fork softly. Strike it again, this time with greater force. Elicit the differences in volume (loudness).

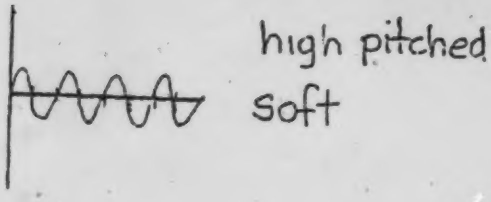
Explain that the loudness of a sound depends upon the energy used to make that sound. Define the width of the wave produced (sound's pattern) as the amplitude.

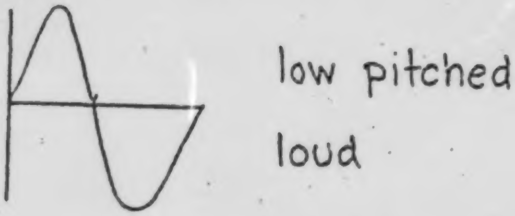
This can be illustrated as follows:

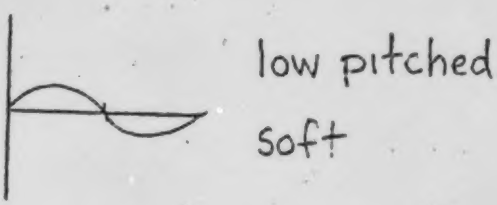

amplitude
Loud


amplitude
Soft


high pitched
loud


high pitched
soft


low pitched
loud


low pitched
soft

9. A slinky may be used to demonstrate some of the different wave forms. If a slinky is not available, a length of heavy rope may be used.

10. Discuss the need for a conducting medium to transmit or carry sound vibrations from the vibrating object to the listener. If a person fires a gun on the moon, will a noise be heard? Explain.

11. Strike a tuning fork. Elicit the conducting medium which carries the sound from the tuning fork to the ears of the listener. A slinky may be used to demonstrate compression waves. Explain that a series of compressions and expansions produce a sound wave.

12. Play a record or tape of loud, annoying sounds. Elicit why these are considered "noise." Noise is usually loud, unfamiliar, and surprising. Define noise as loud, irregular sounds. Explain that the loudness and pitch of noise changes often, usually at irregular intervals.

Enrichment

1. Name 5 sources of noise in your home.
2. What are sound-producing parts of a television, violin, whistle?

ADDITIONAL TEACHER NOTES

Lesson 96 Sources of Noise

Aim: Why is it so noisy?

Materials

noise recording, sound level meter or tape of a fixed tone, tuning fork, Decibel Level Chart (reproduce for distribution)

Objectives

To explain the use of the decibel scale to measure noise
To identify the major sources of noise in the environment
To correlate everyday noises with the decibel scale

Strategies

1. Strike a tuning fork softly, then hard. Review the previous lesson's definition of loudness.

2. Distribute and discuss the Decibel Level Chart. The decibel scale is used to measure loudness. The scale is in multiples of 10. A 70 dB sound is 10 times louder than a 60 dB sound. An 80 dB sound is 100 times louder than a 60 dB sound. Starting from 0, each 10 dB represents a power of 10.

   10 dB is 10^1 times as loud as 0 dB
   20 dB is 10^2 times as loud as 0 dB
   30 dB is 10^3 times as loud as 0 dB
   100 dB is 10^{10} times as loud as 0 dB

3. Elicit some major sources of familiar noise. These might include cars, trucks, subway trains, jet planes, etc.

4. Discuss the disturbing effects of noise. For example, a loud truck is less disturbing during the day than at night.

   55 dB - tolerable in a residential area - daytime
   45 dB - tolerable in a residential area at night

5. Discuss and develop the concept of background noise (the noise level in your environment). Elicit that these noises may be from traffic, people, radios, machines, etc.

6. The sound level meter may be used to measure the background noise in the room. (If a noise meter is not available, play the tape of a fixed level tone). In order to be heard, a sound must be louder than the background noise level.

7. Discuss pleasant and unpleasant aspects of background noise.
   Pleasant- music in a supermarket or restaurant; a softly ticking clock in a bedroom.
   Unpleasant- loud machinery, traffic sounds, talking in a classroom.

8. Discuss sound levels associated with common everyday sources of noise. See Decibel Level Scale.

Enrichment

Describe the sources of background noise in your home, school, and street.

ADDITIONAL TEACHER NOTES

DECIBEL LEVEL SCALE

Because of the thousands of tones audible to the human ear, noise is measured in logarithmic units, decibels (dB), rather than in linear numerical units. 10 dB is not twice as loud as 5, or 40 twice as loud as 20; rather, the noise doubles approximately every 10 dB -- 90 dB is twice as loud as 80. Also, because the human ear is more sensitive to high frequencies than to low ones, measurements are often made on an A-weighted scale, which places more emphasis on high-pitched tones; hence the term "dBA."

The cause and effect of some familiar sound levels culled from the Office of Public Information, Environmental Protection Administration are:

Source of Noise	dBA Level	Physiological Affects
	135-140	Causes pain and hearing damage
jet takeoff at 200 feet	118	Leads to temporary or permanent hearing loss depending on length of time
air compressor at 3 feet	110	
pneumatic drill at 3 feet	105	
	95	Discomfort threshold
train noise: subway platform	90 - 98	
some food blenders	88	
	85	Hearing impared if continuous
car horn at 50 feet	82 - 102	Causes physiolocal reactions, i.e., increased heartbeat and breathing rate
heavy midtown traffic	80 - 85	
loud radio	75	Annoyance threshold
vacuum cleaner at 10 feet	70	Speech interference
dishwasher	50 - 60	

- -

Tolerable Levels

average home	40 - 50	Quiet
optimum sleeping level	35 dBA and less	

Lesson 97 Measurement of Noise

Aim: How can the loudness of a noise be measured?

Materials

sound level meter, copy of dB scale from Lesson 96, tape recorder with a recorded fixed level tone

Objectives

To understand the principles of direct sound measurement
To demonstrate a comparative testing technique to determine noise level
To identify sources of noise in and around the school environment

Strategies

1. This activity is designed to be done either as a direct measurement of noise levels, or a comparative determination of noise levels. These methods may be used separately or together.

2. Before starting, stress the need for quiet during this activity.

3. Arrange a tour plan through the school building and out into the school block. Be sure to include both noisy and quiet areas.

4. At each stop on the tour, take a sound level reading. Students should indicate whether the area is quiet, noisy, or very noisy. (If you do not have a sound level meter, play a fixed level tone at each location). The relative loudness of noise at each stop can be estimated by the ease at which the tone can be heard.

5. As a follow-up activity, have students rate each area in terms of (a) noise level, (b) best place to talk, best place to study, best place to take a test, etc.

ADDITIONAL TEACHER NOTES

Lesson 98 Effects of Noise on Living Things

Aim: What effect does noise have on living things?

Materials

tape recorder, tape of unpleasant sounds, ear model, diagram of human ear (reproduce for distribution)

Objectives

To understand that noise is an environmental problem that can cause physical damage
To identify human noise tolerance levels
To analyze the effects of noise on people
To identify occupations in which noise may be hazardous
To identify methods that can be used to control noise

Strategies

1. Produce a loud, unpleasant noise (drop a heavy object, play a recording of unpleasant sounds). Review the definition of noise.

2. Elicit the responses of the students to unpleasant sounds. List the different responses on the board.

3. Discuss at what point a noise becomes intolerable or hard to take. Point out that studies show that the annoyance threshold for most people is 75 dB.

4. Distribute the ear model chart. Develop a class discussion on how hearing takes place. Point out that sound vibrations are changed into nerve messages in the organ of Corti. In the organ of Corti, hairs of different lengths move back and forth. This back and forth motion corresponds to the sound vibrations entering the ear. At the base of each hair, a nerve fiber sends an impulse to the brain.

5. Elicit how the hairs would move during the transmission of soft or loud sounds; and the transmission of high or low pitched sounds.

6. Explain how a very loud noise might damage the organ of Corti. Very loud noises may cause the hairs in the organ of Corti to break or move so rapidly that they can injure the nerves connected to them. A continuous noise of 85 dB can do this. At 95 dB, noise becomes uncomfortable. At 135 dB or more, noise can cause pain.

7. Discuss signs of hearing damage. Explain that a ringing sensation (tonitis) is the first sign of hearing damage. Other forms of hearing damage include a loss of hearing in all ranges of sound, and partial loss of hearing where only certain pitches or tones are lost.

8. Discuss how a noisy room might affect people. Explain that noise may increase irritability, nervousness, blood pressure, and heartbeat rate.

9. Elicit those occupations or places of work which might be harmful to hearing. Include subways, construction work, air hammer operator, etc.

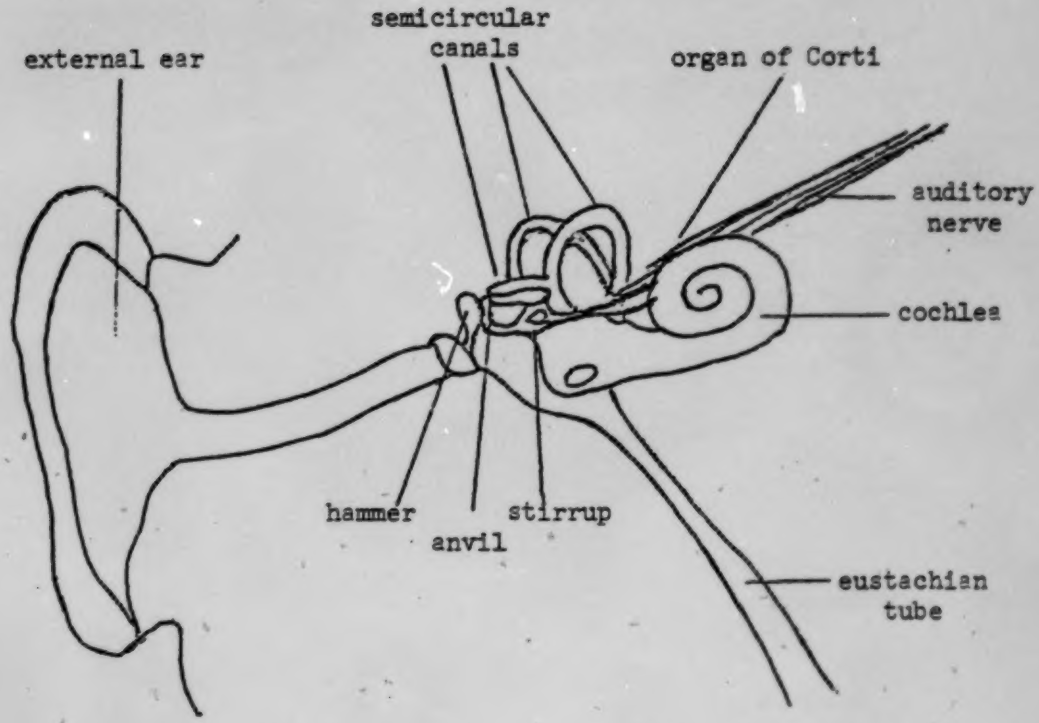
10. Ask students to discuss ways in which noise levels might be controlled. Consider such factors as the use of sound proofing materials and the creation of noise level standards which would make it illegal to produce noise above a certain volume or sound level.

Enrichment

Identify sources of noise in your neighborhood.
  a) Carefully describe each.
  b) Explain how each makes you feel.
  c) What suggestions would you make to eliminate or reduce the noise?

ADDITIONAL TEACHER NOTES

The Human Ear


semicircular canals
external ear
organ of Corti
auditory nerve
cochlea
hammer
anvil
stirrup
eustachian tube

Lesson 99 Importance of Water

Aim: Why do we need water?

Objectives

To understand the need for water by living things
To recognize the properties of water that are essential to living things
To review the finite and cyclic nature of water
To appreciate the importance of water as an environment for living things
To recognize the varied uses that people make of water resources

Strategies

1. Place the following quotation on the board. "When the well's dry, we know the worth of water."
   Ben Franklin

   Elicit the meaning behind this statement.

2. Discuss the importance of air, food, and water to living things. Elicit that without air, organisms could survive only a few minutes; without food, perhaps a month; without water, no more than a few days.

3. Elicit and list some of the major characteristics of water.
   -liquid
   -chemically made of 2 atoms of hydrogen and 1 atom of oxygen
   -odorless
   -tasteless
   -transparent
   -poor conductor
   -good solvent
   -exists in three states - solid, liquid, and gas
   -freezes at $0^{o}C$ ($32^{o}F$)
   -boils at $100^{o}C$ ($212^{o}F$)

4. Use a diagram to describe the water cycle and develop a class discussion regarding the finite nature of water.

5. Discuss and describe the use of water as a habitat for living things. List the variety of organisms that live in the oceans and in bodies of fresh water. Discuss the fact that water is a habitat for developing insect larvae. The water environment is also a source of nutrition for many birds and mammals.

6. Elicit how people use water. Responses should include drinking, cooking, growing plants, household uses, industrial uses, transportation, and recreation.

7. Encourage students to suggest ways in which we misuse our water resources. List examples on the board.

9. If time permits, teachers may want to enrich the lesson by discussing and developing information on water distribution and management. The following may be used for this purpose.

   To help instill an awareness of and appreciation for our water resources, the teacher may want to reproduce this material for class distribution.

Environmental Protection Administration

WATER RESOURCES

Contact 566-0108

September/1976

New York City residents use about 1.5 billion gallons of fresh water each day. The present water supply system represents an expenditure of more than $1.5 billion. The water is obtained primarily from three systems -- Croton, Catskill, and Delaware.

Since 1905, the major water supply facilities for New York City have been designed and constructed by the City's Board of Water Supply. Upon completion, these facitities are transferred for maintenance and operation to the jurisdiction of the City's Department of Water Resources' Bureau of Water Supply.

DISTRIBUTION -- From Upstate to the City

The rain and snow that fall on the ground in the watershed areas (land areas in which falling or flowing water drains to the lowest point) drain into brooks and streams which in turn form creeks and rivers. Dams are built across these creeks and rivers to impound their waters and to form artificial lakes or storage reservoirs. From the controlled lakes and storage reservoirs, the water is drained to meet the daily requirements of the City and some upstate communities to which the City supplies water.

The City owns eighteen reservoirs and four controlled lakes in the some 1,950 square miles of water shed area located in nine upstate counties. Of this, the City owns 90,000 acres (the combined size of Brooklyn, Manhattan, and the Bronx) on which it pays annual taxes to the communities of approximately $20 million -- over one third of the annual Water Supply Bureau's budget.

The storage capacity of the reservoirs and controlled lakes is 550 billion gallons of water. Water is conveyed from these by gravity through large aqueducts ranging in size up to 19 1/2 feet in diameter. Within the City, it is distributed through four local reservoirs and two major tunnels. The entire system can safely be depended on to furnish an average of 1.290 billion gallons a day, even during drought periods.

The Croton system includes 12 reservoirs and 4 controlled lakes, supplying up to 12% of the City's daily needs.

The Catskill system includes 2 reservoirs, supplying up to 40% of the City's daily needs.

The Delaware system includes 4 reservoirs, supplying up to 50% of the City's Daily needs.

In addition the City can utilize -- in emergencies -- up to 100 million gallons per day of Hudson River water through use of a pumping station located about 50 miles upstate from Manhattan.

TUNNELS

The City has two tunnels which carry water from the Hillview Reservoir to the five boroughs. A third tunnel is under construction now and will supplement the two present supply tunnels.

City Tunnel #1 is 18 miles long, up to 15' in diameter and averages a depth of 365 feet. Completed in 1915, it carries Delaware water to the five boroughs.

City Tunnel #2 is 20 miles long, up to 17' in diameter and averages a depth of 500 feet. Completed in 1936, it extends from Hillview Reservoir through the Bronx, Queens, and hooks up with Tunnel #1 in Brooklyn. Recently completed was the 10' diameter, 5 mile long Richmond Tunnel which connects with Tunnel #2 in Brooklyn and carries water to Staten Island.

City Tunnel #3, under construction by the Board of Water Supply, has been termed "one of the engineering wonders of the world." Costing upwards of $1 billion for the first two stages, the tunnel will connect all five boroughs and, for the first time, house underground control centers. The massive 24-foot tunnel, large enough for two freight trains, is part of the first two stages which will take five years to complete. The tunnel will be built in four stages.

DISTRIBUTION -- City-Wide

The City's distribution system consists of a gridiron network of water mains ranging in size from four to 72 inches in diameter. It contains approximately 6,000 miles of pipe, 170,000 valves and 103,000 hydrants. The network is divided into separated zones whose boundaries are determined by street elevations.

The pressure for water fed into each zone is regulated so that it ranges between 35-60 pounds per square inch at street level. This range is sufficient to supply water to the top of a five or six story building. Normally, about 95% of the total consumption is delivered to the network solely under the force of gravity. It is necessary to pump the remaining 5% from delivery to zones of higher elevation in order to keep the pressure within the desired range.

MAINTENANCE

The Bureau of Water Supply employs about 1,900 people who are involved in the operation and maintenance of the water supply system. These include engineers, administrative personnel, foremen and superintendents, inspectors, and unskilled laborers.

The Department has an emergency status similar to the Police and Fire Departments and operates on a round-the-clock basis throughout the year. There are fourteen repair headquarters located throughout the City.

The owner of a building to which water is supplied is responsible for the maintenance of the service connections which extend from within the building to the City main located under the street. The owner must engage a licensed plumber to install or repair these connections. Currently, there are about 794,000 service connections in the City. Any pumping that may be required to furnish water to the upper stories of tall buildings, usually pumped into roof tanks, must be provided by the owner.

UPSTATE COMMUNITIES

New York State law mandates that local communities in the counties our water supply system passes through are permitted to tap the City's water supply system. Therefore, the City presently supplies about 100 million gallons per day to some upstate communities at cost. In Westchester, this amounts to about 75% of its residents' water consumption.

PRIVATE COMPANY

There is only one remaining water supply company operating within New York City, the Jamaica Water Supply Company, supplying 60 million gallons per day for customers in the entire Jamaica area with water taken from wells.

WATER QUALITY

At this time, it is not necessary to filter our water since it is inherently of high quality and the long periods of storage in the collecting and distributing reservoirs serve to reduce the bacterial content and the turbidity. Before the water reaches the consumer, all of it is chlorinated and fluoridated, and some of it is aerated. When required, copper sulfate is used for algae control and occassionally alum for turbidity.

The City owns and operates seven laboratories with approximately 50 bacteriologists, engineers, and chemists who monitor the water. At the labs, 40,000 samples a year are collected and 400,000 annual analyses are performed. The checks are made for 60 different substances, including heavy metals and trace organics. The monitoring program is based on federal and state health agency requirements.

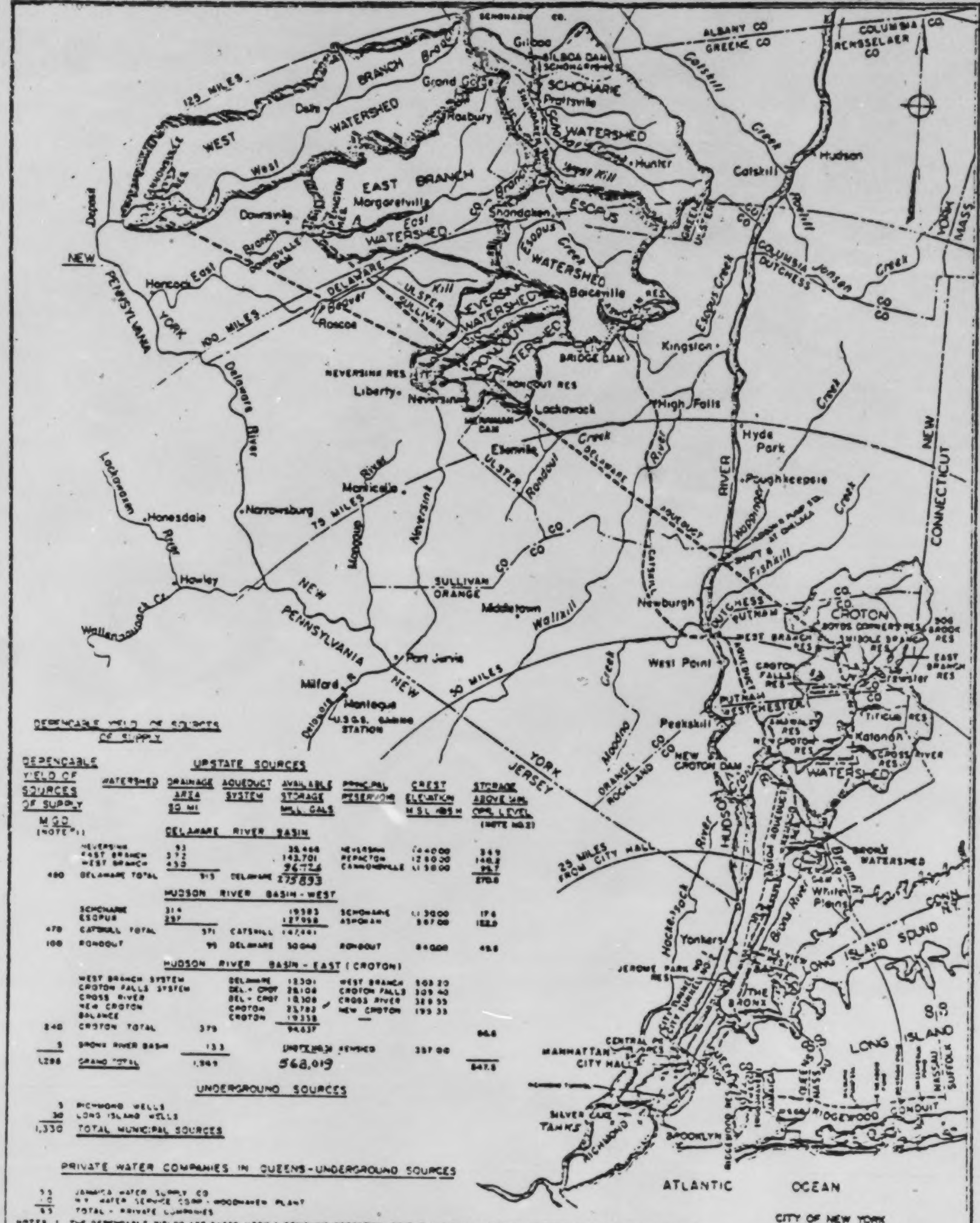
In addition to monitoring, we have watershed inspectors who continuously run sanitary surveys and maintain constant surveillance of our watersheds. They cover not only the reservoirs, but also the streams and treated wastewater which feed into the reservoirs.

The City owns and operates ten sewage treatment plants to treat sewage from communities in the watershed areas. We achieve 98% removal of organic pollutants. The treatment system includes intermittent sand filters which biologically breaks down pollutants in the sewage.

W.S.C. 339

THE WATER SUPPLY OF THE CITY OF NEW YORK

FILE 144


SCHOHARIE CO.
ALBANY CO
GREENE CO
COLUMBIA CO.
RENSSELAER CO
Gilboa
GILBOA DAM
SCHOHARIE RES
SCHOHARIE
WATERSHED
Prattsville
125 MILES
WEST BRANCH
Grand Gorge
Delhi
WATERSHED
Roxbury
Catskill Creek
Hudson
Hunter
Catskill
EAST BRANCH
Margaretville
Downsville
Deposit
Shandaken
ESOPUS
Esopus Creek
WATERSHED
GREENE CO
ULSTER CO
COLUMBIA CO
DUTCHESS CO
Jansen Creek
NEW YORK
MASS.
NEW YORK
PENNSYLVANIA
Hancock
DELAWARE
ULSTER
SULLIVAN
NEVERSINK WATERSHED
Boiceville
ASHOKAN RES
100 MILES
Roscoe
Kingston
BRIDGE DAM
NEVERSINK RES
RONDOUT RES
Liberty
Neversink
Lackawack
MERRIMAN DAM
High Falls
Hyde Park
Ellenville
DELAWARE AQUEDUCT
ULSTER CO
Rondout Creek
RIVER
Poughkeepsie
NEW
CONNECTICUT
Monticello
Mongaup River
Neversink
75 MILES
Lackawaxen
Honesdale
Narrowsburg
Delaware River
Hawley
SULLIVAN CO
ORANGE CO
Wallkill
Middletown
Newburgh
Fishkill
Wallenpaupack Cr.
NEW YORK
PENNSYLVANIA
Port Jervis
Milford
Montague
U.S.G.S. GAGING STATION
50 MILES
West Point
DUTCHESS
PUTNAM
CROTON
WEST BRANCH RES
BOYDS CORNERS RES
MIDDLE BRANCH RES
BOG BROOK RES
EAST BRANCH RES
CROTON FALLS RES
Brewster
PUTNAM
WESTCHESTER
TITICUS RES
Peekskill
AMAWALK RES
NEW CROTON RES
Katonah
CROSS RIVER RES
NEW YORK
JERSEY
ORANGE
ROCKLAND
NEW CROTON DAM
WATERSHED
HUDSON
25 MILES FROM CITY HALL
KENSICO RES
BRONX WATERSHED
White Plains
CONN.
N.Y.
LONG ISLAND SOUND
Yonkers
JEROME PARK RES
THE BRONX
CENTRAL PARK RES
MANHATTAN
CITY HALL
LONG ISLAND
QUEENS
KINGS
NASSAU
SUFFOLK
SILVER LAKE TANKS
RICHMOND
BROOKLYN
RIDGEWOOD
CONDUIT
ATLANTIC OCEAN

DEPENDABLE YIELD OF SOURCES OF SUPPLY

UPSTATE SOURCES

DEPENDABLE YIELD OF SOURCES OF SUPPLY M.G.D. (NOTE NO. 1)	WATERSHED	DRAINAGE AREA SQ. MI.	AQUEDUCT SYSTEM	AVAILABLE STORAGE MILL. GALS.	PRINCIPAL RESERVOIRS	CREST ELEVATION M.S.L. DATUM	STORAGE ABOVE MIN. OPS. LEVEL (NOTE NO. 2)
	DELAWARE RIVER BASIN						
	NEVERSINK	93		35,466	NEVERSINK	1440.00	34.9
	EAST BRANCH	372		143,701	PEPACTON	1280.00	140.2
	WEST BRANCH	450		96,726	CANNONSVILLE	1150.00	95.7
490	DELAWARE TOTAL	915	DELAWARE	275893			270.8
	HUDSON RIVER BASIN - WEST						
	SCHOHARIE	314		19383	SCHOHARIE	1130.00	17.6
	ESOPUS	257		127958	ASHOKAN	587.00	122.9
470	CATSKILL TOTAL	571	CATSKILL	147,441			
100	RONDOUT	95	DELAWARE	50048	RONDOUT	840.00	49.5
	HUDSON RIVER BASIN - EAST (CROTON)						
	WEST BRANCH SYSTEM		DELAWARE	12301	WEST BRANCH	503.20	
	CROTON FALLS SYSTEM		DEL. + CROT.	28104	CROTON FALLS	309.40	
	CROSS RIVER		DEL. + CROT.	10308	CROSS RIVER	329.33	
	NEW CROTON		CROTON	23782	NEW CROTON	195.33	
	BALANCE		CROTON	19338			
240	CROTON TOTAL	375		94,637			86.6
3	BRONX RIVER BASIN	133		(NOTE NO. 3)	KENSICO	357.00	
1,298	GRAND TOTAL	1,949		568,019			547.8

UNDERGROUND SOURCES

3	RICHMOND WELLS
30	LONG ISLAND WELLS
1,330	TOTAL MUNICIPAL SOURCES

PRIVATE WATER COMPANIES IN QUEENS - UNDERGROUND SOURCES

53	JAMAICA WATER SUPPLY CO.
10	N.Y. WATER SERVICE CORP. - WOODHAVEN PLANT
63	TOTAL - PRIVATE COMPANIES

NOTES 1. THE DEPENDABLE YIELDS ARE BASED UPON A COMBINED OPERATION OF THE CATSKILL-CROTON SYSTEMS AND UPON RELEASING WATER FROM THE DELAWARE RESERVOIRS TO MAINTAIN A MINIMUM FLOW OF 1750 C.F.S. AT MONTAGUE AS STIPULATED IN THE 1954 AMENDED DECREE OF THE U.S. SUPREME COURT.

2. THE MINIMUM OPERATING LEVEL IS THE LOWEST ELEVATION OF A RESERVOIR'S WATER SURFACE THAT WILL MAINTAIN A DRAFT IN THE WITHDRAWAL AQUEDUCT AT ITS OPERATING CAPACITY.

3. KENSICO RESERVOIR IS USED FOR REGULATION AND SAFETY AND ITS STORAGE CAPACITY OF 30,573 M.G. IS NOT INCLUDED IN IMPOUNDMENT STORAGE.

CITY OF NEW YORK
DEPARTMENT OF WATER RESOURCES

SOURCES OF WATER SUPPLY

DEC. 1968

0 5 10 15 MI.
SCALE

317

9/34 REVISED - 5/37, 6/39, 7/39, 4/42, 12/53, 4/54, 7/57, 12/64 1/72 10/72

Lesson 100 Measuring Dissolved Oxygen and Biological Oxygen Demand- Lab Activity

Aim: How do organisms get oxygen in an aquatic environment?

Materials

several 1 liter water samples, LaMotte dissolved oxygen test kit

Objectives

To measure the oxygen content of a body of water
To analyze the biological oxygen demand of organisms that live in a body of water
To relate dissolved oxygen (D.O.) and biological oxygen demand (B.O.D.) to the organisms found in a body of water
To relate environmental factors to dissolved oxygen levels

Strategies

1. To illustrate the importance of oxygen, ask students why it is necessary to have an air pump in an aquarium. Elicit that fish, snails, and other organisms require oxygen.

2. Develop the understanding that the most important test for determining the quality of water is the test for oxygen.

3. Explain that dissolved oxygen is oxygen which is dissolved in water at normal air pressure.

4. Elicit how oxygen is used in a body of water. Develop the understanding that the biological oxygen demand (B.O.D.) is a measure of oxygen used by organisms in the water. For example, bacteria are constantly decomposing organic materials into carbon dioxide and water or into nitrites and nitrates. These processes require oxygen. If there are large numbers of organisms in the water, the amount of dissolved oxygen may be reduced to zero. When this occurs, anaerobic organisms (those that do not require oxygen), begin to decompose organic matter. This results in the production of methane and hydrogen sulfide gas.

5. Effluents are materials released into a body of water from factories and sewage treatment plants. Have students discuss how the dumping of organic wastes affects the quality of ocean water.

   Discuss the use of B.O.D. tests to determine the oxygen requirements of an effluent. This test is done regularly at sewage treatment plants. The most common testing procedure involves measuring the amount of oxygen used up over a 5 day period. The results are expressed in parts per million (ppm), e.g., 175 ppm indicates 175 mg of oxygen are consumed by 1 million grams of water (sample) over a 5 day period at 20°C.

Explain that at times, water samples are diluted before making B.O.D. measurements. This is done because a high concentration of bacteria may give a B.O.D. reading that is too great to measure.

6. Use the 1 liter water samples. In order to determine the amount of dissolved oxygen, one of several methods can be used. Either a modification of the Winkler Titration test or packaged forms produced by LaMotte can be used. All steps except the final titration must be done completely and immediately in the field.

7. Discuss the effects of temperature, velocity, and tides on the available D.O.

Enrichment

Untreated sewage water has a B.O.D. of around 600 ppm. How would you suggest that we lower the B.O.D. level?

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 100 How do organisms get oxygen in an aquatic environment?

Name ______________________ Date ____________ Section ____________

Introduction

One of the properties of water that makes it so valuable is the fact that water is a universal solvent. In addition to being able to dissolve solids like salt or sugar, water also has the ability to dissolve gases. Gas molecules can fit in between water molecules. This in fact, is how the carbon dioxide bubbles get into soda; the gas is dissolved in the water before the soda is bottled. As water flows in streams or is whipped up into waves on the ocean, some oxygen from the air dissolves in the water. Green plants that live in the water also produce oxygen which dissolves in the water. The amount of oxygen found in water is called dissolved oxygen or D.O. D.O.is measured in parts per million which means that if a sample of water has 15 parts per million (ppm) of dissolved oxygen, 1,000,000 pounds of the water would contain 15 pounds of oxygen. The D.O. is vital to all forms of life in the water. If it falls too low, life cannot exist. Many things use up the oxygen that is dissolved in the water. Fish, one-celled animals, and even the water plants need oxygen. Their need for oxygen determines the biological oxygen demand in a body of water. Many organic chemicals that are produced by living organisms can use up oxygen along with certain types of bacteria. Of the B.O.D. is high, this means that oxygen is being used up at a very high rate and may not be put into the water fast enough to support many forms of life. A low B.O.D. might mean that for some reason, there are very few forms of life living in the water tested.

I. Measuring D.O.

Materials

LaMotte dissolved oxygen kit

NOTE: The first two steps of this test are the most important. Follow all kit instructions carefully.

Procedure

1. Alkaline iodide and manganese sulfate are added to the water sample to be tested. The sample is taken very carefully so that no additional air can dissolve in the water.
2. Sulfuric acid is added to the water sample. This chemical "locks" the oxygen in the water and forms a compound that can be analyzed. It prevents any additional oxygen from getting into the sample.
3. The sample is then tested with an indicator solution which changes color when all the oxygen has been tested for.

II. Measuring B.O.D.

Materials

two jars, water, plastic spoon, yogurt, methylene blue solution, incubator

NOTE: In this activity, you will set up two jars; one with tap water and one with tap water to which ½ spoonful of yogurt has been added. The bacteria in yogurt will imitate the action of living things on organic wastes.

This is a simulated test which actually takes 5 days to complete.

Procedure

1. Place 100 ml of tap water into a jar.
2. In a second jar, place 100 ml tap water and ½ spoonful of yogurt.
3. Add 1 ml of methylene blue solution to each jar. The methylene blue will stay blue as long as oxygen is present in the water. When the oxygen disappears, the methylene blue will turn colorless.
4. Place both jars into an incubator and compare them the following day.
5. You may wish to try this at home so that you can watch the jars to find out exactly how long it took for the color change to take place. Remember, the faster the color changes, the faster the oxygen in the water is being used up.

Lesson 101 Types and Sources of Water Pollution

Aim: Why is some water not fit for use?

Materials

LaMotte water testing kit

Objectives

To understand the inability of bodies of water to purify themselves when they contain large amounts of polluting material

To identify the types and sources of water pollution

Strategies

1. Discuss the implications of the following statement from the Rime of the Ancient Mariner: "Water, water everywhere, but not a drop to drink."

2. Ask the class where their last drink of water came from. What important features of our water resources does this indicate?
   - the amount of water is finite
   - water is constantly recycled and thus is used over and over again

3. Explain that a total of more than 300 billion gallons of water are used each day. What are the implications? Elicit that we are running out of water; some reasons are:
   a) increasing population
   b) greater use per person
   c) greater industrial use
   d) greater agricultural use

4. Explain that in addition to our greater use of water, we have also increased pollution. For example:
   a) municipal sewers contribute 40 billion gallons of effluent in various types of treatment
   b) agricultural processes release 50 billion gallons of effluent
   c) industry releases 125 billion gallons of effluent
   d) storm runoff from rural areas contains sediment and fertilizers
   e) storm runoff from urban areas contains street and road pollutants

5. Elicit and discuss those materials responsible for water pollution.
   - saline wastes
   - acid wastes
   - organic wastes: fertilizers, sewage
   - animal wastes
   - infectious agents such as bacteria
   - radioactive substances
   - thermal pollution

Arrange for your class to visit a local beach, river, lake, etc. If this is not possible, bring a variety of water samples to class. Water samples can be tested for chemical substances using the LaMotte water test kits. Tests for D.O., pH, CO_2, alkalinity, hardness, and salinity will enable the class to get some idea of the nature of the body of water being studied. Discuss the meaning of the results; let students suggest how and why the water chemistry might change.

Review some of the types of water pollution.
- sedimentation
- plant nutrients
- oil
- salt water seepage
- mining waste
- industrial wastes
- sewage

ADDITIONAL TEACHER NOTES

Lesson 102 Bacterial Pollution

Aim: How can we tell if water is safe?

Objectives

To understand the role of bacteria in water ecosystems
To understand why coliform bacteria are used as pollution indicators

Strategies

1. Elicit the beneficial aspects of bacteria present in the ocean. Discuss the importance of decomposers (saprophytic bacteria) which break down dead organisms but consume large amounts of oxygen.

2. Develop the understanding that some bacteria are disease causing (pathogenic) while others are non-pathogenic. Most bacteria are non-pathogenic.

   Discuss the fact that sewage contains a variety of pathogenic and non-pathogenic bacteria. Elicit that of all forms of water pollution, one of the most dangerous is pollution by bacteria. The most common source of bacterial pollution in the New York City area is the emptying of untreated sewage into the waters that surround the city.

3. Elicit how we determine whether or not a body of water contains pathogenic bacteria. Explain that knowing that there is some sort of bacterial pollution in a water sample is not quite enough to declare water unsafe for drinking, bathing, or fishing. A test is needed to determine the numbers of bacteria present in a given sample of water. The more bacteria present, the more polluted is the water.

4. Explain that E. coli is a non-pathogenic bacteria that lives in the intestines of humans. These bacteria are referred to as coliform bacteria. The presence of E. coli indicates the pollution of water by fecal material. This warns us of the potential for pathogenic bacteria being present. Pathogenic bacteria include those forms that cause typhoid, cholera, hepatitis, tetanus, scarlet fever, whooping cough, diphtheria, meningitis, and tuberculosis.

5. Explain that standards for water uses are established by local health and environmental officials. There are standards for swimming, drinking, and eating of animals caught.
   - for drinking purposes: less than 1.1 bacteria/100 ml sample
   - for taking fish: less than 70 bacteria/100 ml sample
   - for swimming: less than 2,400 bacteria/100 ml sample

Lesson 103 Effects of Water Pollution

Aim: What are the effects of polluted water?

Materials

2- 500 ml beakers, 2 small goldfish, boiled water (allowed to cool to room temperature), pictures that illustrate some positive and negative aspects of New York City's waterways

Objectives

To recognize the health hazards caused by water pollution
To appreciate the effects of water pollution
To understand the effects of water pollution of aquatic ecosystems

Strategies

1. Demonstrate the effect of excess heat on a water sample by performing the following demonstration.
   a) Fill one of the beakers with tap water at room temperature.
   b) Fill the other beaker with water that has been boiled and allowed to cool to room temperature.
   c) Place a small goldfish into each beaker.
   d) Assign student volunteers to count the breathing (gill) movements for each fish.
   e) Remove the fish from the boiled water sample after sufficient data is obtained.

   Elicit what happened to the oxygen level in the water that was heated. Ask students how they can tell this happened. Discuss circumstances under which thermal pollution might occur. What results might this have on aquatic organisms?

2. Americans are often cautioned about the drinking water in foreign countries. Discuss how we can eliminate the problem of bacterial pollution. Elicit how water pollution affects our beaches and food supplies.

3. Discuss how water pollution limits recreational activities.
   - fish are killed
   - swimming is often prohibited
   - boating is limited by odors and floating debris

4. Anaerobic bacteria produce ammonia and hydrogen sulfide. Both of these gases have extremely unpleasant odors. Also, the presence of anaerobic bacteria increases the potential for pathogens. In general, anaerobes may result in a decline of the esthetic value of an area. Have students suggest other pollutants that have similar effects.

5. Use pictures to motivate the positive and negative aspects of New York City's waterways.

6. If possible, study the animal life of a body of water. When a body of water becomes polluted, it changes from one containing many species of moderate population, to few species of high population. Why does this occur?

7. Discuss eutrophication. Explain that discharging large quantities of chemicals such as fertilizers and detergents into a body of water may result in a temporary over-population of algae. As these simple plants die, an increased growth of bacteria causes much oxygen to be used. This results in very low levels of dissolved oxygen in the water.

Enrichment

1. Investigate the effect of oil spills on shore animals.
2. Why does eutrophication result in the death of most living things in a lake?

ADDITIONAL TEACHER NOTES

Lesson 104 Sewage Treatment

Aim: What happens to our dirty water?

Materials

diagram of sewage treatment plant (reproduce for distribution)

Objectives

To recognize the need for sewage treatment
To understand the various types of treatment that are used
To understand the processes involved in water treatment
To appreciate the problems that are associated with sewage treatment

Strategies

1. Challenge students to explain how the water in an aquarium is kept clean. Elicit that carbon filtration and biological filtration are two commonly used methods.

2. Discuss how sewage is treated. Explain that sewage treatment involves one or more processes. Each additional form of sewage treatment produces a better quality water. Ask students to discuss what might occur if no sewage treatment took place. Point out that on the west side of Manhattan, wastes are dumped directly into the Hudson River.

3. Discuss how sewage is collected. Explain that sewage is collected through a sewer system consisting of either separate or combined storm and sanitary sewers. In the combined system, interceptors allow excess sewage to pass directly into the receiving waters.

4. Elicit the need for sewage treatment. Explain that the natural cleaning process cannot efficiently handle the huge volumes of sewage involved. Bacteria that normally perform the decomposition require oxygen. A large amount of organic wastes seriously deplete the level of oxygen available. This demand for oxygen is called the biological oxygen demand.

5. A diagram of a sewage treatment plant will aid in explaining the following outline of sewage treatment.

   Primary Treatment
   Mechanical process used to remove solids from the water.
   a) Screening to remove floating objects.
   b) Grit chamber where grit is allowed to settle.
   c) Sedimentation tanks are used to settle-out suspended solids. These solids are collected as raw sludge.
   d) Waste water is chlorinated to kill disease-causing bacteria and to reduce odor.

Secondary Treatment

Biological process using bacteria to rapidly decompose organic wastes.

a) Trickling filters are beds of stone or other synthetics, through which sewage is passed. Bacteria among the stones decompose organic matter.
b) Activated sludge processing is the mixing of water from primary treatment, with air and bacteria-containing sludge which is held for several hours.
c) Sedimentation and chlorination

Tertiary and Advanced Treatment

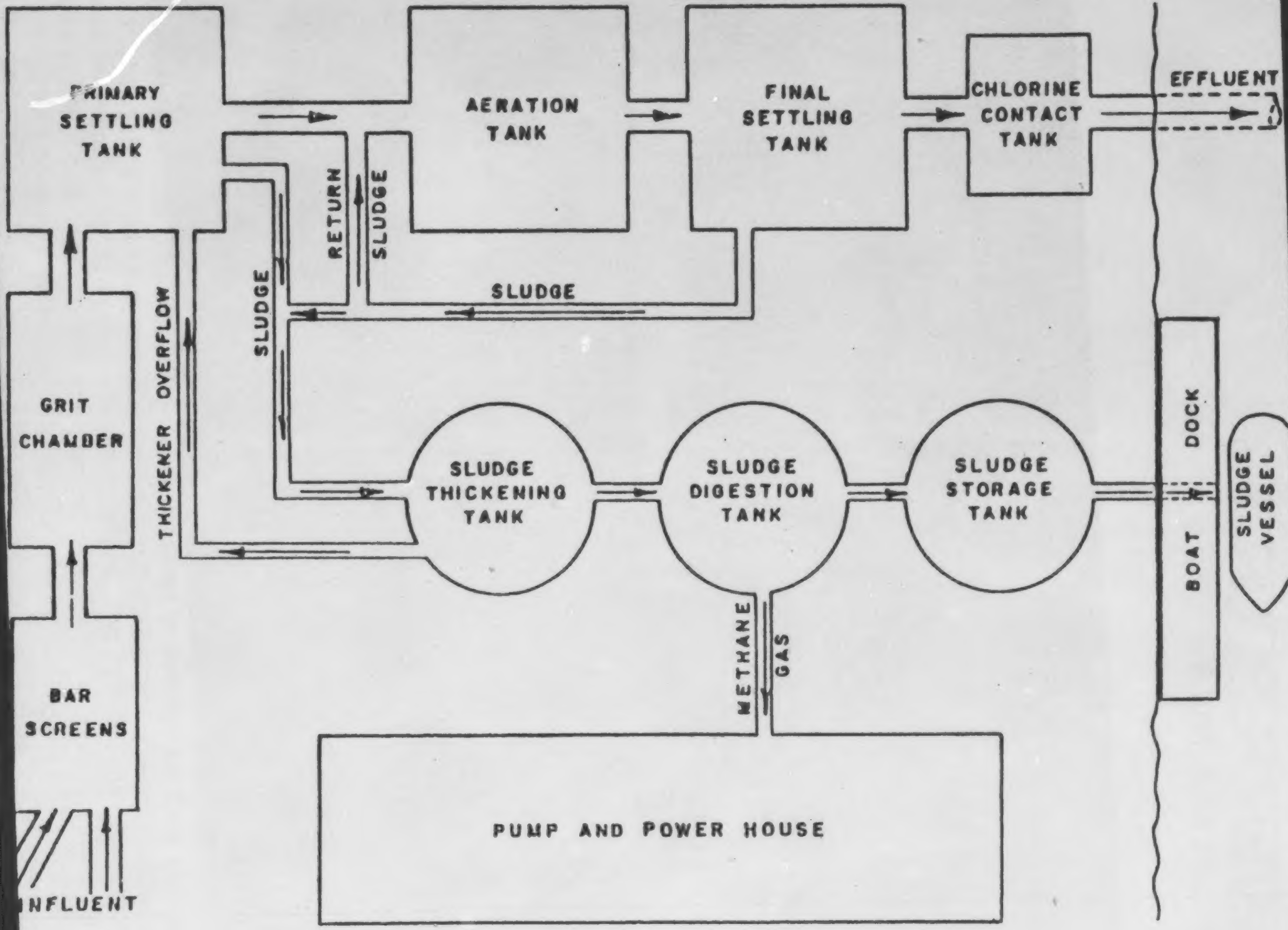
These are physical and chemical treatment processes that can be used after primary and secondary treatment. The following are some of the possible methods:

a) Coagulation- sedimentation removes all suspended solids and reduces the concentration of phosphates. Chemicals known as flocculants are used to bunch together these materials.
b) Carbon absorption involves passing effluent through activated charcoal to remove organic matter.
c) Electrodialysis can be used to reduce dissolved salts electrically.
d) Reverse osmosis removes wastes from water by using semi-permeable membranes.
e) Land disposal or living filters involve using soil for its decomposing abilities. Sludge is used as fertilizer while liquid waste, containing suspended and dissolved nutrients, is chlorinated and sprayed on the soil.

6. Discuss the cost of sewage treatment. Explain that New York City uses more than 70 million gallons of water per day. The cost of processing that part of the water that ends up in treatment plants may be as high as 5 cents per 1000 gallons for just primary treatment. Secondary treatment costs an additional 10 cents per 1000 gallons and tertiary treatment may cost up to 20 cents per 1000 gallons.

7. As added enrichment, teachers may wish to distribute the following information which fully describes the operation of a New York City water pollution control plant.

LAYOUT OF A TYPICAL N.Y.C. WATER POLLUTION CONTROL PLANT



PRIMARY SETTLING TANK
AERATION TANK
FINAL SETTLING TANK
CHLORINE CONTACT TANK
EFFLUENT
RETURN SLUDGE
SLUDGE
SLUDGE
THICKENER OVERFLOW
GRIT CHAMBER
BAR SCREENS
INFLUENT
SLUDGE THICKENING TANK
SLUDGE DIGESTION TANK
SLUDGE STORAGE TANK
DOCK
BOAT
SLUDGE VESSEL
METHANE GAS
PUMP AND POWER HOUSE

Environmental Protection Administration

WATER RESOURCES

Contact 566-0108

OPERATION OF A TYPICAL NEW YORK CITY WATER POLLUTION CONTROL PLANT

Sewage is the water supply of the community which has been polluted by use in the home and industry. Until fairly recently, the disposal of waste-water was not considered to be a problem. Sewage was merely allowed to flow into the nearest body of water, thus solving the problem, it was thought, by dilution.

However, with a rapidly expanding population and a sharp increase in industrial wastes, the hazards of this practice became apparent. Large parts of the United States are now familiar with contaminated drinking water, the loss of marine life and water fowl, condemned bathing beaches, and the unsightly appearance of once-beautiful water areas.

It is now generally agreed that water pollution control is essential, and many systems of sewage treatment have been devised. They include septic tanks, Imhoff tanks, crushed stone trickling filters, sand filter beds, plain sedimentation, and activated sludge.

Septic tanks are widely used for homes in sparsely populated areas, where sufficient land is available for tank drainage and a central sewage system would be impractical. Imhoff tanks are used mainly by larger institutions such as hospitals and schools which do not have access to a central sewer system.

Many cities and towns use trickling filters. These are relatively simple and effective, but require larger areas than are available in metropolitan communities such as New York City.

The choice of a sewage treatment system in a local community is determined by factors such as volume of sewage, availability of land, and the nature of the receiving waters into which the process effluent is to be discharged. Circumstances dictate that the New York City plants must process large volumes of sewage, with a high degree of efficiency, in very limited spaces, and often in close proximity to residential areas. Those conditions can best be met by a treatment process using activated sludge. The operation of a typical New York City plant of this type is outlined below.

PRELIMINARY TREATMENT

The treatment process begins when the raw sewage, or INFLUENT flows through the BAR SCREENS, which consist of two series of upright bars spaced about one and three inches apart. Large objects, such as rags and sticks, are removed at the bar screens by automatic raking devices. The present trend in bar screen construction is one set of bars spaced one inch apart.

A considerable amount of sand and gravel, or GRIT, enters the city sewer system through street drains, especially during rain. It is necessary to remove this grit soon after it enters the plant in order to protect pumps and other equipment from abrasion, and to prevent a build-up of grit deposits in subsequent treatment tanks. In older designs a GRIT CHAMBER is used and is designed to slow the velocity of the sewage to about one foot per second. At this reduced speed the heavier, inert particles settle, and are removed from the tank by a scraping mechanism. The lighter, organic impurities, which will require additional treatment, remain suspended in the sewage flow. In upgraded plants the grit chamber is no longer used. Instead, the grit is allowed to enter the PRELIMINARY SETTLING TANK with the sewage.

PRIMARY TREATMENT

The sewage is allowed to settle for about one hour in the PRIMARY SETTLING TANK. During this time about one-third of the suspended organic impurities settle and form a SLUDGE, which is removed from the bottom of the tank by pumps. A small amount of scum and grease rise to the top and is removed by a rotating mechanism that skims the surface. In plants where grit chambers are not present, grit settles in the primary settling tank and becomes mixed with the primary sludge. In order to separate the grit from the sludge, the mixture is pumped to a cyclone separator, where, under the action of centrifugal force and because of different specific weights, the two are separated.

SECONDARY TREATMENT

Secondary treatment begins in the AERATION TANK, where sewage is detained from three to six hours, depending on the particular type of process employed. During this time the sewage is supplied with compressed air from diffusers near the bottom of the tank.

The impurities remaining after primary sedimentation are freely suspended or dissolved in the sewage. The purpose of the aeration tank is to convert the dissolved and suspended solids into particles which will settle in a relatively short time. This transition in the nature of the suspended solids is mainly biological. It is accomplished by AEROBIC BACTERIA, which thrive in the aeration tank due to the presence of oxygen and the organic impurities in the sewage which serve as their food supply. These bacteria build up around the particles of organic matter, and then, by the process of absorption, cause the individual particles to combine into clusters. Within these clusters most of the organic matter is either consumed by the bacteria or converted into simpler, stable compounds.

The accumulation of bacterial clusters in the treatment tank is called a FLOC, and one of its most important properties is a good settling quality.

The aeration tank is followed by the FINAL SETTLING TANK, where most of the suspended solids will now readily settle and form a sludge which is removed from the bottom of the tanks by pumps. Detention time is two to three hours, after which the clarified sewage, or FINAL EFFLUENT, flows from the plant into the receiving waters.

ACTIVATED SLUDGE

Since the conversion of suspended solids into settleable sludge is effected by aerobic bacteria, it is obvious that the number of these bacteria in relation to the amount of suspended solids in the aeration tank will determine the efficiency of the process. In a system of plain aeration the biological activity in the aeration tank is limited to what can be accomplished by the aerobic bacteria which occur naturally in the sewage. Although these bacteria multiply during the detention period, they are constantly being lost as the sewage flows from the tank. As a result, the proportion of bacteria to suspended solids remains too low to achieve more than moderate treatment efficiency.

The system of ACTIVATED SLUDGE solves this problem by returning some of the settled solids, or sludge, from the final settling tank to the aeration tank. Since most of the bacterial culture is concentrated in the sludge, it is possible to maintain an adequate bacteria population in the aeration tank with a relatively low sludge return.

TREATMENT AND DISPOSAL OF REMOVED WASTES

The 12 operating water pollution control plants in New York City process over one billion gallons of sewage each day. Thousands of tons of sludge and solid matter are removed daily, and of course it is necessary to dispose of these wastes without adding to the pollution problems.

Grit, rakings from the bar screens, and the skimmings from the primary settling tanks are removed by truck and deposited at sanitation landfills. These substances, however, make up only a small fraction of the material removed. Sludge, which contains most of the impurities removed from the sewage, requires additional treatment before it is finally disposed of.

THICKENING

In order to reduce treatment and transport costs, it is necessary to remove as much water as possible from the sludge. This is accomplished by placing the sludge in a special settling tank which is called a THICKENER. After settling for a period of 12 to 24 hours, a large amount of the water separates from the sludge. This water is returned to the sewage flow at the beginning of the plant and the remaining concentrated sludge, or THICKENED SLUDGE, is pumped from the bottom of the tank to the Digester.

DIGESTION

Because it consists of raw putrescible solids, sludge cannot be used for landfill and must be disposed of at sea. For this reason it is desirable to reduce the pollution potential of the sludge as much as possible before it is released from the plant.

The DIGESTER is a large, enclosed, circular tank in which sludge is detained for a few weeks at a temperature of about 95 degrees. These conditions favor the growth of ANAEROBIC BACTERIA, which proliferate in the absence of oxygen. These bacteria obtain their nourishment by breaking down the organic compounds and in this manner convert about 50 percent of the organic matter in the sludge to various gases and water. The gas produced by digestion is composed essentially of METHANE and carbon dioxide, and many plants use it to generate all or most of their power requirements.

The digested sludge is then pumped into a SLUDGE STORAGE TANK, where it will await shipment to sea by one of the City's four self-propelled sludge vessels. These ships, of varying capacities up to three thousand wet tons, (100,000 cu. ft.) dispose of the sludge about 12 1/2 miles out at sea, in a federally designated dumping area.

CHLORINATION

Even the most efficient water pollution control plant does not remove all of the impurities from the sewage. PATHOGENIC BACTERIA may be present in the plant effluent, and so, during the summer months the plants disinfect their effluent in order to protect local bathing beaches from contamination.

The most effective and economical disinfectant available for sewage treatment is CHLORINE. However, in its liquid and gaseous states chlorine is extremely dangerous and difficult to handle. Therefore, since 1965 New York City plants have applied chlorine in the form of SODIUM HYPOCHLORITE, which is stored in the plant in special tanks.

Disinfection takes place in the CHLORINE CONTACT TANK, where the plant effluent is detained for an average of 30 minutes in order to insure a thorough destruction of bacteria. The plant effluent is sampled frequently during the summer in order to assess the efficiency of disinfection. About 99.999 per cent of the coliform bacteria in the final effluent are killed by hypochlorination.

Lesson 105 Clean Water Standards

Aim: What's being done to clean up water?

Objectives

To identify new technologies that could be used to control water pollution
To appreciate the need for alternate sources of clean water
To understand the present laws used to maintain water standards
To suggest additional methods of water pollution control

Strategies

1. What can we do to insure clean water for the future? Are our present treatment processes sufficient?

2. Suggest ocean water as a future source of drinking water. Discuss whether desalination is a useful method in allowing us to make use of ocean waters. Consider an average cost of $1.00 per 1000 gallons.

3. Challenge students to discuss how public awareness through education might play a role in avoiding serious water shortages. What can the public do to help?

4. Discuss the Federal Water Pollution Control Act of 1972. Indicate that this act is an attempt to clean United States waterways by preventing, reducing, and eliminating water pollution. The general goals of the act are to:
   a) get water clean enough for recreation and protection of wildlife by 1983
   b) have no discharges of pollutants into waterways by 1985

5. How will this law be enforced? Explain that individual states will have primary responsibility to prevent, reduce, and eliminate pollution. The Environmental Protection Agency will insure compliance with the law. Deadlines are set for controlling industrial pollution. Federal grants are made available to municipalities to construct waste water treatment plants. Specific water quality standards are expanded to all United States waters.

6. Elicit why we have garbage washing up on local beaches despite all of the efforts being taken to clean up our waterways. Discuss the New York Bight dumping area and the creation of a "dead sea" in this once thriving fishing area. What are the alternatives?

7. Discuss the role of the individual and of local, state, and federal governments in controlling pollution. How might these agencies act to control pollution?
   Consider the following:
   a) oil dumping: heavy fines for failure to observe anti-water pollution regulations

Lesson 106 Solid Wastes

Aim: What do you "throw away?"

Materials

photographs of abandoned cars, garbage accumulations, littered highways, and streets

Objectives

To recognize the characteristics of solid wastes
To classify solid waste materials
To relate the production of solid wastes to the needs of modern society

Strategies

1. Show photographs illustrating solid wastes. Point out that all solid wastes have one important feature in common; they are not wanted anymore.

2. Identify different types of solid waste.
    a) garbage- food scraps, peels, leftover meat trimmings
    b) trash- paper, cardboard, wood
    c) rubbish- plastic, metal, glass

3. Elicit which of the three types of solid waste would decompose first if left outside on the ground. Why? Point out that some types of solid waste, particularly garbage, are biodegradable. This means that they can be broken down by such soil organisms as worms, fungi, and bacteria.

4. Show some pictures of solid waste. Discuss where each type of solid waste comes from and the particular problem it creates. Abandoned autos are dangerous and unsightly. Garbage accumulations can become breeding areas for rats. Some solid waste can get into water causing water pollution.

5. Elicit the meaning of the expression, "use it and throw it away." Point out that we live in a culture in which we very often will throw something out rather than repair it and use it again.

6. Challenge students to suggest practical uses for one-way bottles or cans.

7. One of the most common types of solid waste is packaging material. Why is it so important to have so much packaging? Discuss the uses of attractive, bulky packaging to get people to buy certain products. What can be done to control this form of waste?

  - limit oil tanker ports
  - restrict offshore drilling
  - control ballast dumping

b) sewage: construction of separate sewer systems for carrying storm water and waste water

c) industrial wastes: heavy fines for discharging effluents into waterways
  - recycling of industrial waste water
  - tax incentives for use of pollution control devices

Enrichment

What penalty should be imposed on a major industry for discharging toxic pollutants into a river?

ADDITIONAL TEACHER NOTES

Lesson 107 Uses of Solid Wastes

Aim: What can be done with solid wastes?

Materials

pictures of junked cars, samples of clean solid wastes, white glue, oaktag

Objectives

To appreciate the need for recycling wastes
To understand how solid wastes are recycled
To recognize the use of solid wastes as an alternate source of energy
To construct a garbage collage or other useful objects from household

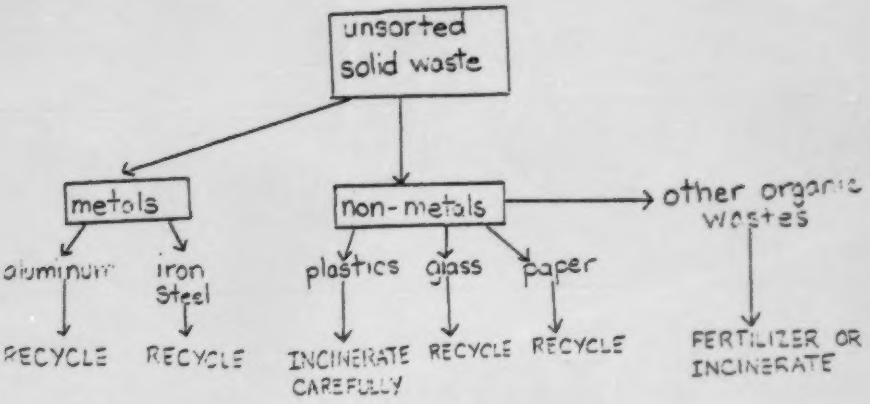
Strategies

1. Show pictures of junked cars. Discuss the need for avoiding this type of build-up of solid waste in our environment.

2. List some of the more common types of litter found in the school or school neighborhood. Classify each as:
   a) biodegradable- able to be broken down by living organisms
   b) recyclable- able to be used over again
   c) non-recyclable- unable to be used over again

   Some examples of each: banana- biodegradable
   aluminum can- recyclable
   plastic cup- non-recyclable

3. Discuss methods of recycling materials. Use the following as a model.


unsorted solid waste
metals
non-metals
other organic wastes
aluminum
iron Steel
plastics
glass
paper
RECYCLE
RECYCLE
INCINERATE CAREFULLY
RECYCLE
RECYCLE
FERTILIZER OR INCINERATE

4. Elicit how solid wastes may be recycled and used.
   a) aluminum may be melted and used to produce new aluminum goods
   b) iron and steel may be melted down and mixed with iron ore

   c) glass can be crushed and mixed with rubber or asphalt to make paving materials
   d) envelopes, books, and other types of stationary can be made from recycled paper

5. Review how electric power is generated.

   boiler ⟶ steam ⟶ turbine ⟶ generator

   Discuss the possibility of using combustible materials in solid wastes as a source of fuel.

6. Biodegradable materials such as food scraps can be used to make fertilizers. Discuss mulch piles and compost heaps.

7. Some pieces of clean solid waste can be glued to a piece of oaktag. Sack "garbage art" demonstrates one simple use for solid waste. While constructing the "garbage collage" discuss some other uses to which solid wastes may be put.

Enrichment

1. Do you save aluminum cans for recycling? If not, why?
2. What problems could you think of if you were required to bring back bottles and cans to the grocery store?

ADDITIONAL TEACHER NOTES

Lesson 108 Disposal of Solid Wastes

Aim: Is there a place for it all?

Materials

pictures of garbage dumps, landfills, incinerators, and filled-in open pit mines

Objectives

To understand the design of a sanitary landfill
To understand the function of a municipal incinerator
To analyze the problems related to ocean dumping
To identify an alternate disposal method

Strategies

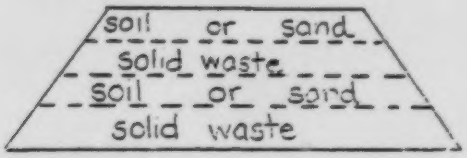
1. Motivate the lesson by stating that New York City produces approximately 24,000 metric tons of solid waste each day. Challenge students to explain where it all goes.

2. Discuss the differences between a dump and a landfill. Explain that a dump is an open area where garbage and other wastes are indiscriminately piled. This garbage is burned in open fires.

3. Elicit why the open burning of garbage is a poor practice. Point out the trade-off of solid waste for air pollution.

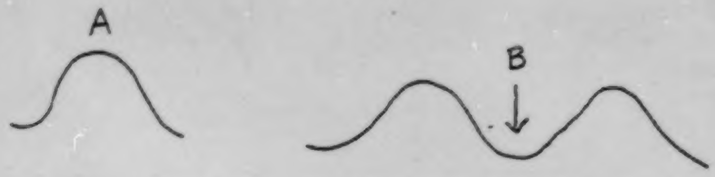
4. Evaluate open dumping. Discuss open dumps as homes for rats, roaches, and other vermin.

5. Review the role of decomposers in soil formation. Elicit how we could take advantage of decomposers in the disposal of certain types of solid waste. Construct a diagram of a sanitary landfill area. As solid wastes (mostly garbage) are allowed to stay buried under a layer of soil or sand, decomposers start to convert the solid wastes into usable soil materials.



6. Elicit why this is referred to as a sanitary landfill. Point out that properly covered fills do not attract rats, mice, or other pests because the garbage is underground.

7. Elicit whether all areas are suitable for landfill. Draw the following illustration on the board.



Elicit which of the two areas (A or B) are more suitable for landfill.

Point out that all of New York City's landfills (Brooklyn, Pelham, Arthur Kill, and Edgemere), are on lowlands.

8. By 1985, New York City will fill in all of its available landfill sites. What else may be done with 24,000 metric tons of refuse a day? Discuss incineration or burning. Municipal incinerators operate at very high temperatures and allow very little oxygen to come into contact with the material being burned. This avoids the production of many air pollutants. Plastics contained in today's household garbage release hydrogen chloride gas when burned.

9. Elicit the potential dangers caused by dumping garbage into the oceans. Point out that organic materials can combine with oxygen in the water. This would result in very low oxygen levels in the water. State that ocean dumping has created a "dead zone" in the Atlantic Ocean.

10. Discuss some alternate disposal methods and uses for solid wastes. These include filling in open pit mines, and mining landfill for methane (a gas produced by decomposers).

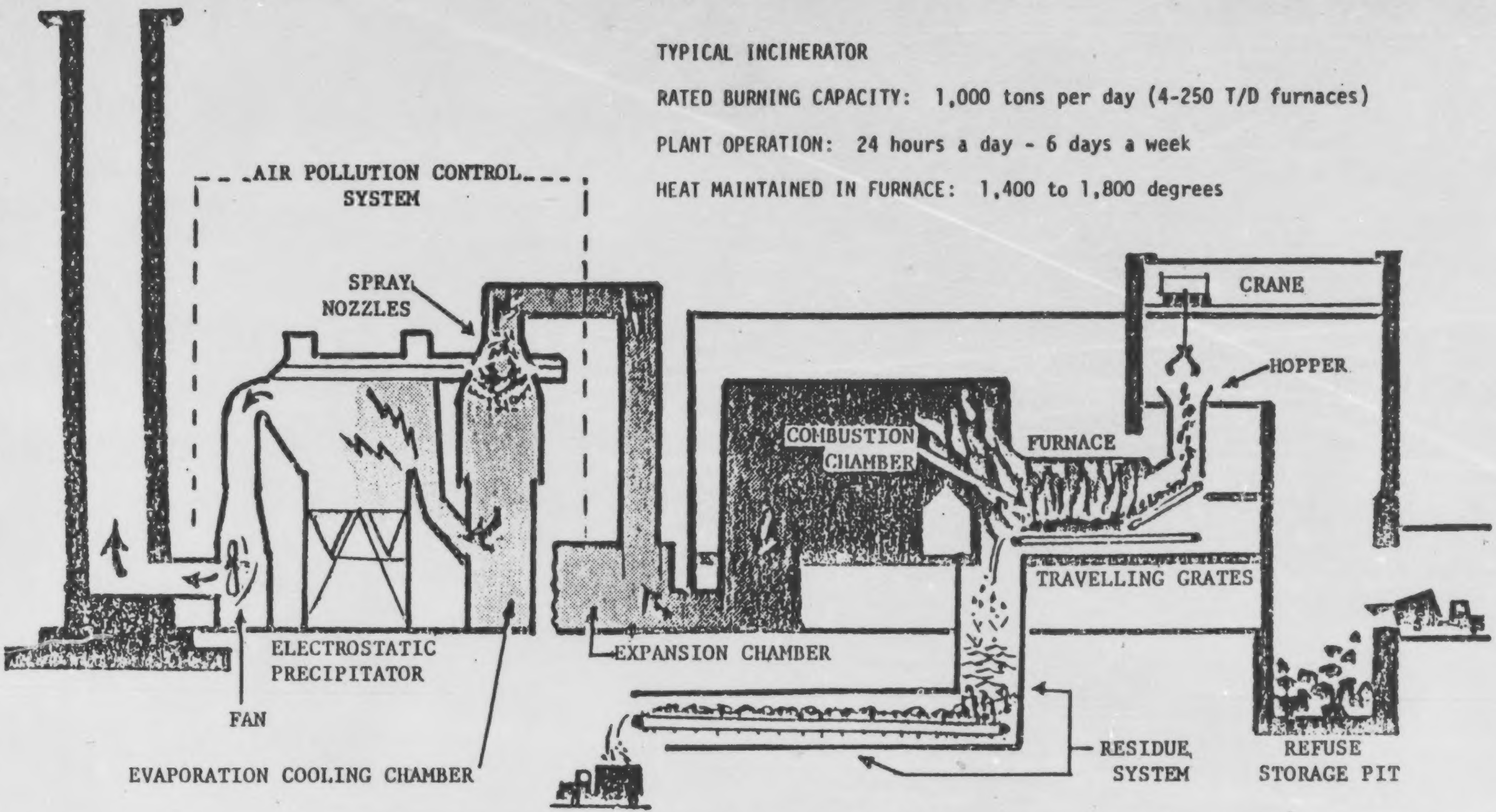
11. The following maps and charts are included for enrichment purposes. Teachers may want to reproduce these for student distribution.

TYPICAL INCINERATOR

RATED BURNING CAPACITY: 1,000 tons per day (4-250 T/D furnaces)

PLANT OPERATION: 24 hours a day - 6 days a week

HEAT MAINTAINED IN FURNACE: 1,400 to 1,800 degrees



STORAGE PIT--- Material is stored here for as long as 24 hours in order to permit the incinerator's around-the-clock operation in the face of the 8-hour collection shift. The pit is concrete to assure strength and water tightness, and to prevent rat-harborage.

CRANES--- Two large overhead electrically-driven bridge cranes rapidly lift refuse from the pit and discharge it near roof level into hoppers--- from which material is fed continuously into furnaces, by gravity, through metal chutes.

FURNACES--- Plants built since 1948 have 30' x 8' furnaces equipped with continuous feed traveling grate type stokers except for Southwest Brooklyn which will have the double reciprocating type stoker. Refuse is fed continuously and is burned, stoked and automatically advanced to the discharge end.

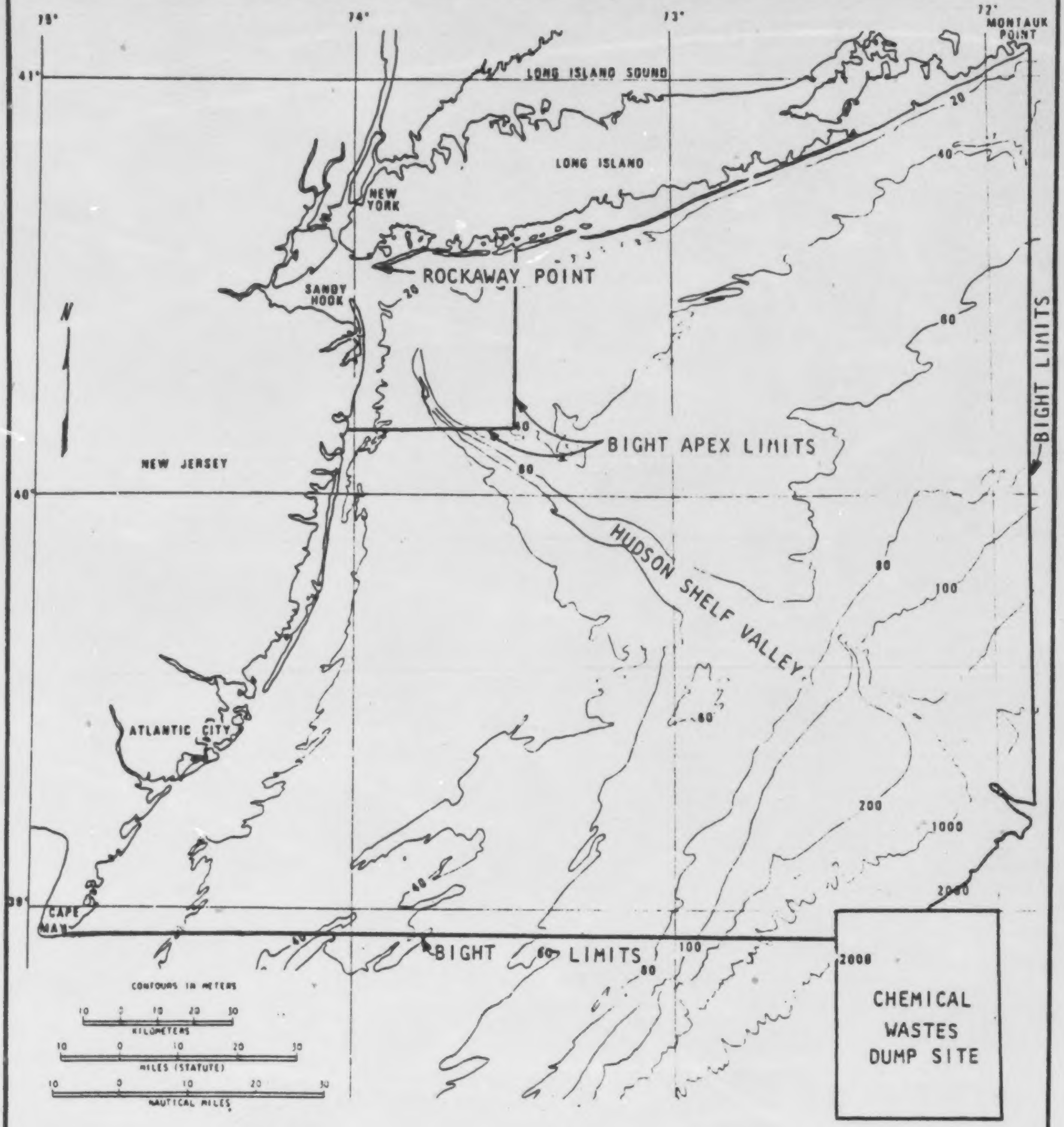
RESIDUE SYSTEM--- At the discharge end of the furnace, burned-out refuse, now consisting of ashes, tin cans and similar unburnt materials is dropped into a concrete lined bath of water for fire-quenching. Cooled residue then is dragged up a long inclined chute to remove as much water as possible. The dewatered residue is dropped into large open body trucks for conveyance directly to a landfill or to a marine transfer station.

COMBUSTION CHAMBERS--- As material is burned on the grates at combustion chamber temperatures of 1600° F. to 1800° F., fine ash and gases are released. Gaseous discharges from the combustion chamber pass through the expansion chamber for more complete combustion and the removal of the heavier particles of fly ash by settlement.

ELECTROSTATIC PRECIPITATOR--- Hot gases from the expansion chamber pass through an evaporation cooling chamber where a water spray cools the gases to 575 degrees. The gases pass between electrically charged electrodes and the fly ash becomes ionized and attracted to the collector plates. The cleaned gases then flow through the induced draft fan to the chimneys.

EXHAUST STACKS--- Large 200-foot chimneys (two stacks for four furnaces) discharge the cleaned gases of combustion to the atmosphere.

NOTE: All other Department of Sanitation Incinerators operate on the same basis as above.

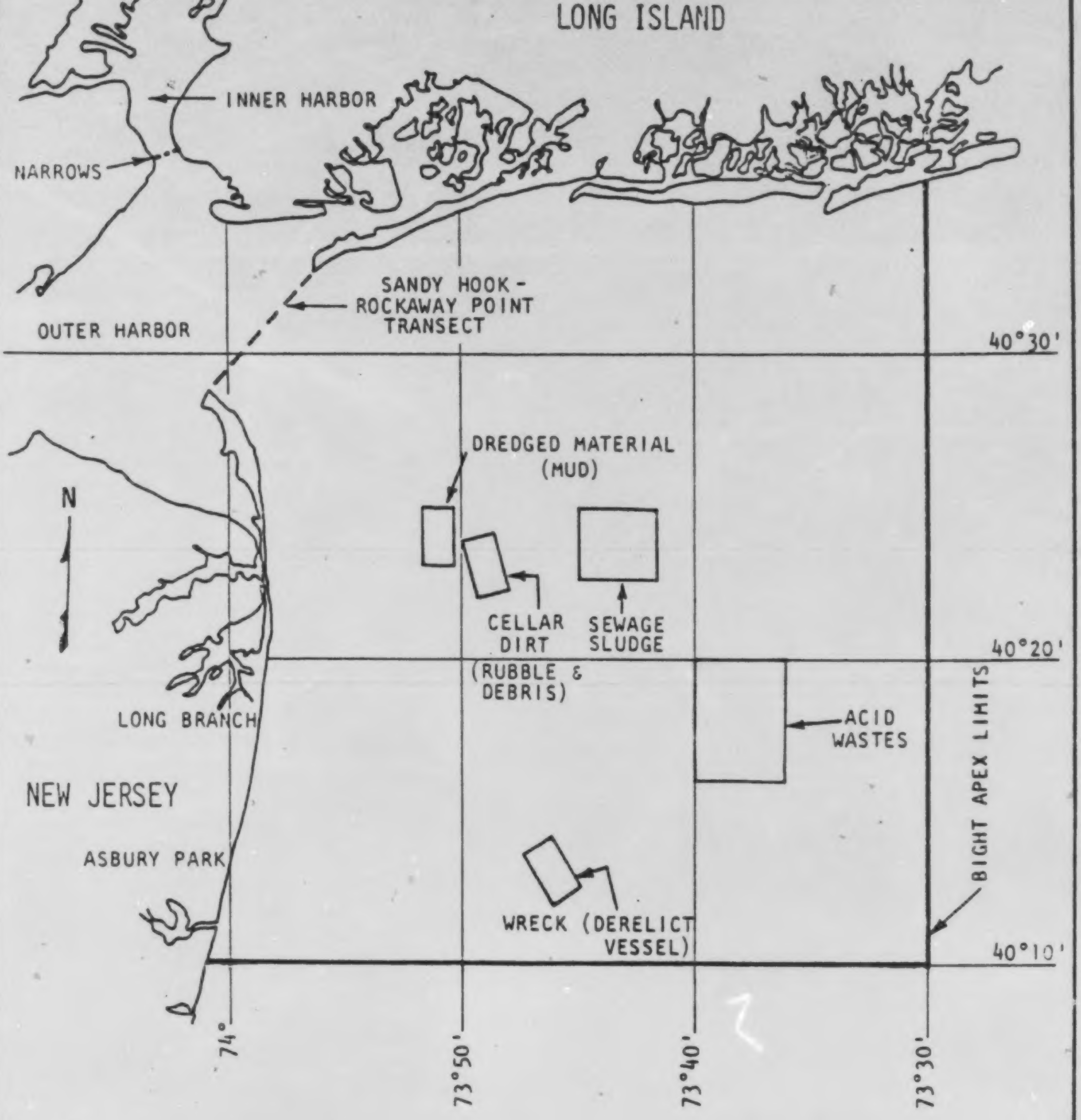

75°
74°
73°
72°
MONTAUK POINT
41°
LONG ISLAND SOUND
LONG ISLAND
NEW YORK
ROCKAWAY POINT
SANDY HOOK
N
20
40
60
80
100
200
1000
2000
BIGHT APEX LIMITS
BIGHT LIMITS
NEW JERSEY
40°
HUDSON SHELF VALLEY
ATLANTIC CITY
CAPE MAY
39°
BIGHT LIMITS
CHEMICAL WASTES DUMP SITE
CONTOURS IN METERS
KILOMETERS
MILES (STATUTE)
NAUTICAL MILES

THE NEW YORK BIGHT

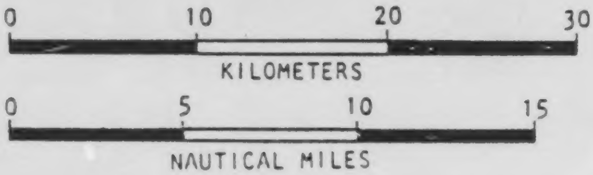
SOURCE: USEPA, APRIL 1975.

DAMES & MOORE

FIGURE 1


LONG ISLAND
INNER HARBOR
NARROWS
OUTER HARBOR
SANDY HOOK - ROCKAWAY POINT TRANSECT
40°30'
DREDGED MATERIAL (MUD)
N
CELLAR DIRT (RUBBLE & DEBRIS)
SEWAGE SLUDGE
40°20'
LONG BRANCH
ACID WASTES
BIGHT APEX LIMITS
NEW JERSEY
ASBURY PARK
WRECK (DERELICT VESSEL)
40°10'
74°
73°50'
73°40'
73°30'

BIGHT APEX AND EXISTING DUMP SITES


0
10
20
30
KILOMETERS
0
5
10
15
NAUTICAL MILES

SOURCE: USEPA, JULY 1974.

DAMES & MOORE

FIGURE 2

Lesson 109 Radioactive Wastes

Aim: What do you do if it's too hot to handle?

Materials

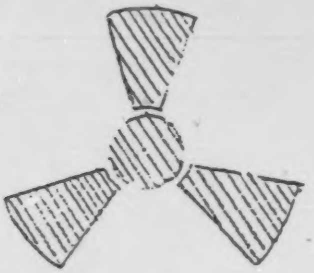
pictures or diagrams of reactors, pictures of metal drums used to store radioactive wastes

Objectives

To understand the nature of radioactive waste material
To recognize the dangerous nature of radioactive wastes
To appreciate the problems involved in the disposal of radioactive wastes

Strategies

1. Display the international symbol for radioactivity.



   Elicit the types of materials on which this symbol would be found.

2. Review the nature of radioactivity and types of radiation (alpha and beta particles and gamma rays).

3. Show pictures of a typical reactor and review the structure of the reactor core. Point out that as time goes by, the efficiency of the reactor decreases because of the accumulation of non-radioactive atoms in the core.

4. Point out that the core of a nuclear reactor can be removed. Elicit reasons for the removal of the core. Emphasize the need for periodic removal and replacement of the core to prevent a "nuclear accident."

5. What dangerous effects might a person suffer if exposed to the radiation from a radioactive core. Discuss increased cases of leukemia, lung cancer, bone cancer, radiation sickness, etc.

6. Elicit and discuss some possible methods for safely packaging, transporting, and disposing of radioactive waste materials.

7. Place the following on the board.

METHOD	ADVANTAGES	DISADVANTAGES
A. bury underground	convenient, does not pollute air or water	some underground sites have shown signs of leakage
B. put in a non-rusting container and dump at sea	easy, for removal from cities and towns	container often does not stand up to the corrosive effects of salt water
C. separate out usable radioactive material and recycle	allows for the recycling of a resource	expensive
D. place in deserted mines	deep, underground, away from everything	possibility of leakage

8. Discuss some other sources of radioactive wastes.
    a) radioactive isotopes used in industry and medicine
    b) radioactive tailings or leftovers from uranium ore processing
    c) coolant that has been used over and over in reactors

9. Why are radioactive materials not allowed over certain bridges or through certain tunnels? Discuss the problems of shipping such materials by truck.

10. Some environmentalists have stated that most radioactive materials are more trouble than they are worth. Discuss this statement.

ADDITIONAL TEACHER NOTES

Lesson 110 Biocides

Aim: How can I get rid of that pest?

Materials

pictures or preserved specimens of common pests, cans or packages of some common biocides

Objectives

To understand the nature of biocides
To recognize the various classes of biocides (broad vs. narrow range)
To understand the mode of action of different biocides
To understand the relationship between the development of biocides and the needs of society

Strategies

1. Elicit that some organisms are considered pests. Discuss what makes pests undesirable. Elicit that pests may cause disease, become unwanted house guests, and compete with people for food or valuable crops. Examples of some pests are:
   a) Arachnids- ticks, mites, chiggers
   b) Insects- termites, roaches, gypsy moth
   c) Birds- blackbirds, starlings
   d) Mammals- mice, rats
   c) Plants- weeds

2. Explain that substances known as biocides or pesticides are used to reduce the numbers of offending organisms to a level where these no longer present a hazard. Some biocides have been developed for use against specific pests while others might be effective against a group of organisms. Elicit the following examples:
   a) insecticide- insect killer
   b) herbicide- weed killer
   c) fungicide- kills fungus and mold
   d) rodenticide- kills rodents (mice and rats)

3. Explain that the history of biocide use has shown many changes in the use and availability of various types of pesticides.

   Before World War II, a variety of salts made from copper or arsenic were used. Other biocides were extracted from plants having a natural resistance, e.g., turpentine (pines), nicotine (tobacco), pyrethrum (chrysanthimums), rotenone (derris). These met the needs of the people. Farms were small and diversified. Farm labor was plentiful. Farming methods were favorable for blocking large build-ups of pests. Small hand-planted fields could be easily cleared of pests by farmers as they tended their crops.

4. In 1939, the properties of DDT (dichloro-diphenyl-trichloroethane) which made it useful as an insecticide were discovered. It was the

first of a group of compounds known as chlorinated hydrocarbons to be developed as a pesticide. Chlorinated hydrocarbons are broad-spectrum biocides; they are effective against all types of insects. This type ofbiocide was needed for the change in agricultural practices that took place after World War II. Farms became large and industrialized. They began to grow only one or two crops, determined by the region of the country.

5. Other examples of biocides known as chlorinated hydrocarbons include:
   insecticides- BHC, heptachlor, dieldrin, endrin, aldrin, mirex, and chlordane
   herbicieds- 2.4 - D (broad-leaved plants), 2.4.5 - T (woody plants)

6. Explain how biocides work. Develop the understanding that biocides used before World War II frequently contained arsenic. How did these compounds affect living organisms? These compounds are considered to be stomach poisons. They would affect only those organisms that have actually eaten the poisonous salts, which then enter the digestive system and poison the animal.

   The recently developed synthetic biocides, such as the chlorinated hydrocarbons, are contact poisons. They enter the organisms through the body wall or the respiratory system; they can affect either the respiratory, nervous, or circulatory systems.

Enrichment

Perhaps our greatest rivals are the insects. Discuss the following:
a) In what ways are insects our rivals?
b) How have we come to deal with these rivals?
c) Give some examples of problems created by insects.
d) How do various methods of insect control affect people?

ADDITIONAL TEACHER NOTES

Lesson 111 The Effects of Pesticides

Aim: What effects do pesticides have on an ecosystem?

Materials

pictures or articles relating to the environmental effects of pesticides

Objectives

To understand the effects of persistent biocides
To understand how some organisms develop a resistance to certain biocides
To trace the path of a biocide through a food chain- biological magnification
To evaluate the effects of biocides upon the members of the biotic community

Strategies

1. Explain that many fruits and vegetables should be washed before they are eaten. Elicit the reason for this. Develop the concept that farm-grown produce is sprayed with various insecticides.

2. Guide students to an understanding that the application of a persistent pesticide (DDT) will not only kill insects that are considered pests, but that it has many side effects on the environment as well.

3. Pose the following question. If DDT can kill insect pests, what what effects does it have on the other insects and organisms in the ecosystem? Elicit that it kills all insects, the beneficial as well as the pests. This is known as nonselectivity.

   Encourage students to consider the following. A farmer has a fruit orchard that is plagued by aphids and caterpillars. In order to get rid of these insects, the farmer sprays the entire orchard with a broad-range biocide. The farmer inspects the orchard over the next few weeks and notices that there are very few insects living there. The farmer also notices that the trees bear very little fruit and that few birds are present.

   Challenge students to explain the cause and effect relationships that have taken place. Elicit that the insecticide killed all of the insects including the pollinators (bees, wasps, butterflies). The source of food for many of the birds had been killed. The birds moved to a new location.

4. Discuss how it might be possible for some insects to survive the biocide spray. Explain that some insects have a natural immunity to DDT or other similar biocides; this is known as resistance. Insects that survive pass on this immunity to their offspring. After many

repeated applications of the same biocide in the same area, species of insects become strongly resistant to that biocide.

5. Although biocides such as DDT are not easily dissolved in water, they do dissolve easily in the fat of living organisms. The level of pesticides in soil, air, or water may be low. However, the pesticides become more concentrated as they enter living things and become involved in the food chain. All the pesticide that an organism takes in with its food accumulates in its body. This is known as biological magnification.

6. Construct a food web using the following marine organisms. Review the expression of concentration in ppm (parts per million).

water	0.00005 ppm DDT
plankton	0.04
minnow	0.94
needlefish (predatory fish)	2.07
tern (feeds on small fish)	3.91
herring gull (scavenger)	5.53
fish hawk (osprey) egg	13.8
merganser (fish-eating duck)	22.8

7. What effects do biocides have on other living organisms in an ecosystem? Much of the information from natural ecosystems comes from the study of birds.
   a) robins- heavy mortality rate due to eating earthworms contaminated with a fungicide used to combat Dutch Elm disease.
   b) birds of prey- falcons, hawks, eagles, ducks, ospreys, brown pelicans- decline believed to be due to DDT. It reduces the bird's ability to provide calcium for egg shells, resulting in breakage while the eggs are incubated.
   c) fish- biocides affect the nervous system of both freshwater and saltwater fish. They can cause instability, respiratory difficulty, sluggishness, and death. Biocides often kill millions of fish at a time.
   d) mammals- laboratory studies of rats, mice, hamsters, dogs, and monkeys have shown that under experimental conditions, some biocides increase the incidence of cancer, birth defects, and genetic mutations. In humans, careless handling of biocides by agricultural workers and children have resulted in death. This is why it is very important to read the label of instructions on any biocide. In seals, mother seals fail to recognize their own offspring and may kill them. This has been traced to large quantities of insecticide concentrated in fatty tissues in their bodies.

Enrichment

Compare and discuss the role of various insecticide ingredients.

Lesson 112 Determining the Effects of Insecticides- Lab Activity

Aim: How do insecticides affect living things?

Materials

2 petri dishes, filter paper or cotton, insecticide solution (commercially prepared- rotenone, lindane, of chlordane), medicine dropper, radish seeds, glass marking pencil

Objectives

To analyze the effects of insecticides on a radish seedling
To define the effects of insecticides on the environment
To compare the advantages and disadvantages of insecticides

Strategies

1. Review the definition of insecticide with the class.

2. Elicit the uses of insecticides. Discuss the harmful as well as beneficial effects.

3. Describe and discuss the laboratory activity. Stress the need for avoiding direct contact with the insecticide.

ADDITIONAL TEACHER NOTES

STUDENT LABORATORY WORKSHEET

Lesson 112 How do insecticides affect living things?

Name ______________________ Date ____________ Section __________

Introduction

Insecticides have been used widely by farmers, homeowners, and apartment dwellers to control insect pests. Too often these chemicals have been used without thinking about the effect they might have on the environment. The wide use of insecticides has been linked to changes in behavior in seals, the softening of bird eggshells and to the killing of many plants. In this laboratory activity, you will be able to observe the effects of an insecticide on a representative organism; the radish seedling.

Materials

2 petri dishes, filter paper or cotton, insecticide solution, medicine dropper, radish seeds, glass marking pencil

Procedure

1. Place a piece of filter paper or cotton in each petri dish.
2. Soak the filter paper or cotton in one dish with insecticide solution. Use the medicine dropper provided.
3. Carefully rinse the dropper and soak the padding in the other dish with water.
4. Place 10 radish seeds in each dish.
5. Cover and label the dishes.
6. Place each dish in a cool, dark place. Observe each dish every 24 hours. Enter your observations on the student data sheet.

Post Lab Questions

1. What do your results indicate?
2. According to your results, when would be the worst time for a farmer to spray his fields?
3. Discuss some possible alternatives to using insecticides.

STUDENT DATA SHEET

Lesson 112 How do insecticides affect living things?

Name ____________________ Date ______________ Section ________

Effect of Insecticides on Radish Seeds

	Number of Germinating Seedlings	
Observation	With insecticide	Without insecticide
1		
2		
3		
4		
5		
6		
7		

Lesson 113 Biological Control of Insects

Aim: How can insect pests be controlled without insecticides?

Materials

pictures of insect predators (lady bug, praying mantis, robin, frog, etc.)

Objectives

To suggest alternatives to the use of biocides
To analyze the use of an integrated control program

Strategies

1. Explain that the use of DDT and many other wide-range insecticides are now banned or under strict government control. Challenge students to suggest available methods of insect control other than poisons.

2. Discuss insect sterility as a means of control. In this program, insect pests are bred in the laboratory and then sterilized. The sterilized forms are then released to mate with the normal population; however, no offspring are produced. This method has already proven successful on certain insects and may be developed for use on other species.

3. Another method is the use of sex attractants known as pheromones. Certain species of insects are very sensitive to the effects of pheromones. Some male moths can follow the trail of pheromone left by the female of the same species over many miles. Scientists are trying to identify the compounds used as sex attractants for each species of insect pest. How can pheromones be used to control insect pests? They can be used with traps, or can be sprayed through the air making it impossible for a male to find a mate.

4. Explain that certain compounds control the development of an insect from egg, to larva, to adult. Identify these compounds as juvenile hormones. Juvenile hormones must be present during certain stages of development, and absent during others. This hormone can prevent insect eggs from hatching and cause immature insects to die.

5. Discuss insects as part of a food chain. This being so, insects must have natural predators or parasites. Challenge students to name some organisms that pray on insects. Examples are fish, birds, mammals, and other insects (lady bug, praying mantis, etc). Explain that by increasing the numbers of natural predators in an area, the numbers of insect pests can be reduced.

6. Discuss the development and use of resistant crop varieties. Of what advantage are these?

7. Agricultural practices of farmers can be of help in reducing the numbers of pests: proper sanitation, destruction of crop residues, deep plowing, rotation of crops and animals on the land, planting of certain crops in strips, and proper timing in planting.

8. Guide students to the understanding that no one method will completely control or exterminate undesirable insects. Probably the best solution is to use several pest control methods in a certain sequence and at proper times, perhaps even with the limited use of some insecticide. This is known as an integrated control program.

Enrichment

1. In New York State a person can be fined for killing a praying mantis. Why is this insect protected by law?
2. List the advantages of an integrated control program over the general use of biocides in controlling pests.

Lesson 114 Chemical Pollution

Aim: How do the things we eat, drink, and breathe affect our health?

Materials

ingredient list from several prepared foods

Objectives

To identify types of chemical pollutants
To recognize the sources of chemical pollutants
To explain the effects of chemical pollutants on living organisms
To understand the relationship between chemical pollution and occupational hazards

Strategies

1. Read the following to the class.

   "Today we are plagued with chronic diseases that an increasing number of health experts believe are largely caused by environmental factors - where we work or live, our habits, diets or lifestyles. The more sophisticated and sensitive our monitoring devices become, the more data we accumulate on the health effects of pollutants and other agents in the environment and, the worse things look."

   Russell E. Train
   Administrator, U.S. E.P.A.

   Discuss recent events concerning the harmful effects of various chemicals, i.e., pesticides, mercury, PCB, kepones, etc. Elicit the contamination of tuna with mercury and the contamination of fish in the Hudson River with PCB.

2. Identify the various classes of chemical pollutants.
   - inorganic pollutants: mercury, lead, cadmium, beryllium, asbestos
   - organic pollutants: food additives, artificial sweeteners, food dyes, pesticides
   - radioactive pollutants: reactor wastes, wastes from hospitals and research facilities, and nuclear testing

3. Discuss the effect of some of the known chemical pollutants.
   a) "Legionaires" disease caused by an unknown substance, possibly a bacterial toxin
   b) Miminata disease caused by mercury poisoning in Japan
   c) The effect of DDT on the eggs of the osprey.
   d) The cancer causing or carcinogenic effect of food dyes and artificial sweeteners.

4. Elicit how some people are affected by the industrial processing of various substances. Include the effect of:

a) kepone on factory workers
b) asbestos on factory workers and mechanics
c) coal dust and coal gas on miners

5. Encourage a class discussion as to what might be done to alleviate the problem of chemical pollution.

Enrichment

What penalties should be imposed on companies that dump toxic materials into our waterways?

ADDITIONAL TEACHER NOTES

Lesson 115 Cancer and the Environment

Aim: How can living be hazardous to your health?

Materials

chart of cancer cells, articles relating environmental factors to cancer

Objectives

To identify carcinogenic substances
To define cancer in terms of cell growth
To evaluate a report on an environmental health hazard

Strategies

1. What is cancer? Discuss the nature of this type of disease. Stress the difficulty that medical science is having in trying to understand the nature of cancer.

2. What causes cancer? Many substances are believed to be responsible for cancer. Basically these substances interfere with normal cell metabolism. Those materials that are responsible for cancerous growth are called carcinogens.

3. Identify various carcinogenic agents and describe how we may come into contact with these substances.
    a) food additives
    b) pesticides
    c) asbestos
    d) beryllium
    e) radiation

    We may have been in contact with these materials many years ago. They could have been in foods; in the air; in the water; at home; at our place of work.

4. Cancer has become a major cause of death since 1900. Cancer of the respiratory system has shown the most rapid increase. Why should this have been an even greater problem in urban areas?

5. Use articles that describe a specific incident to highlight a discussion of environmental factors that cause cancer. There are also many films available that may deal with this topic. These should be checked on an individual basis.

Enrichment

1. Should we accept scientific findings on animal research than concludes that a substance could cause cancer in humans? Explain.
2. It is right for smokers to smoke where there are nonsmokers? Support your opinion.

UNIT IX

ENVIRONMENTAL ANALYSIS

Unit IX is designed to familiarize the student with the various types of environmental action programs available to help the individual solve environmental problems. The student is given the opportunity to examine the roles of local, state, and federal agencies in solving environmental problems. As the students examine the possibilities of various types of environmental action programs and legislation, they will also learn to recognize the importance of individual action in solving environmental problems.

In the culminating lesson, various environmental careers are presented to the student. The purpose of this is to orient students to the growing field of environmental technology.

Lesson 116 The Environmental Crisis

Aim: Can we survive?

Objectives

To identify various environmental crises
To examine current environmental issues
To evaluate the long-term effects of various environmental problems

Strategies

1. Have each student prepare s short report or outline on an environmental issue that he or she thinks needs attention. Use these reports as a basis for discussion and summary of environmental issues.

2. Elicit some of the major categories of environmental problems. Include such areas as:
   a) pollution
   b) population
   c) health
   d) natural environment destruction
   e) land use
   f) energy
   g) contamination- pesticides, detergents, metal poisoning, radiation

3. Encourage students to rank order these problem areas.

4. Discuss the long term effects of the various problems. How much longer can these problems go on?

5. What is our Environmental Ethic? Construct an Environmental Ethic from suggestions made by the class.

Enrichment

Assess the Environmental Ethic suggested by the class and write your own list. Include some things you could personally do.

ADDITIONAL TEACHER NOTES

Lesson 117 The State of the Environment

Aim: How can the "pulse" of our environment be measured?

Materials

completed community questionnaire

Objectives

To identify local environmental problems of the community

NOTE: Distribute the community questionnaire to the students 1 or 2 days before the lesson. Urge the students to have the questionnaire filled out by a responsible member of the community and returned.

Strategies

1. Tabulate those items which lend themselves to tabulation.

2. Interpret the results of the questionnaire with the class. Consider such factors as:
   a) What do people like about their block?
   b) What do people dislike about their block?
   c) How might the attitude of the people toward their block affect the way it looks?
   d) In what ways are the blocks in your neighborhood unique?

3. Discuss the "quality of life" in your neighborhood. How does the condition of a person's environment affect the quality of his or her life? For example, can a person really be happy watching T.V. if all of the buildings in the neighborhood are burnt out and the streets are covered with barbage?

4. Many sociologists claim that crime, drug addiction, and violence are reactions to poor environmental conditions. Discuss this claim. What environmental factors might play a part in encouraging these types of behavior. Point out that inner-city conditions often encourage negative behavior.

5. Go "round robin" around the room. Have students state one positive and one negative aspect of their local environment. Stop every now and then. Challenge a student to explain how he or she is affected by that particular environmental aspect.

QUESTIONNAIRE

Lesson 117 How can the "pulse" of our environment be measured?

Dear Community Member:

The students at ______________________________ are taking a survey on the community. The purpose of this survey is to see how community members feel about their community and what they think should be done to improve it. Although the results of this survey will be tabulated and discussed in class, they may also be used to inform the proper city agencies about corrective actions which may be required to upgrade the community.

Your cooperation is greatly appreciated. Thank you!

1. How long have you lived on the block? ______________________________

2. Do you like living on the block? __________

3. Do you rent or own the place where you live? _______________

4. Are you employed? _________ If so, what do you do? ___________________
____

5. Age ____________ Male or female _____________

6. How many people live with you? ____________

7. What are their ages and sexes? ____________________________________

8. Do you find the block attractive-looking? ________________________
unattractive? ___________________ neither? _______________________

9. Do you ever use the street as a place to chat, sit in the sun, play games? Briefly describe the ways in which you use the street. _________
____

10. If additions were made on the street, which of the following would you like to see: a) additional lighting _____ b) banners _____ c) benches or seats _____ d) community bulletin board _____ e) more attractive paving _____ f) painted wall murals _____ g) fresh paint on fences, building fronts, etc. _____ h) trees and plants _____

11. If a vacant lot on the block or neaby is available, would you like to see it cleaned up, decorated and turned into: a) a small park ______ b) a playground ______ c) a garden ______

12. If street changes are made, should they be designed especially to serve any of these groups: a) children _____ b) elderly people ______ c) young adults ______ d) adults ______ e) teenagers ______ f) everyone ______

13. Where on the block would you like to see changes? At the ends __________ which one? (or both) ____________ in the middle ______ elsewhere _______ (please indicate where) ____

14. Do you think the kinds of changes suggested in this questionnaire would be popular or unpopular on the block? ____________________________ Please give the reason for your answer: ________________________________

____

15. What suggestions could you make for improving your block? ______________

____

____

____

Lesson 118 The Role of the Government in the Environment

Aim: Is it legal?

Materials

copies of various environmental laws and guidelines (available from city, state, and federal agencies)

Objectives

To understand the structure of local, state, and federal government in handling environmental problems
To acquaint students with existing environmental laws
To understand how an environmental law is enacted

Strategies

1. Place the initials E.P.A. on the board. Use the following headline as an example: "E.P.A. sets clean air standards for New York." What do the initials E.P.A. stand for? Elicit that these letters stand for the Environmental Protection Administration.

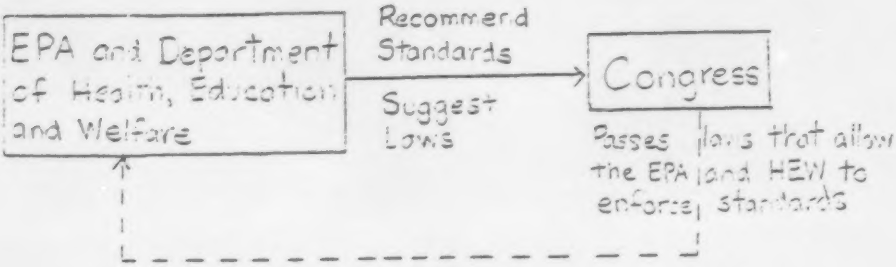
2. Challenge students to explain what is meant by the term "clean air standards." Review the meaning of safe levels of pollution.

3. Why are safe standards important? Emphasize the need to prevent the slow destruction of the environment by the activities of people.

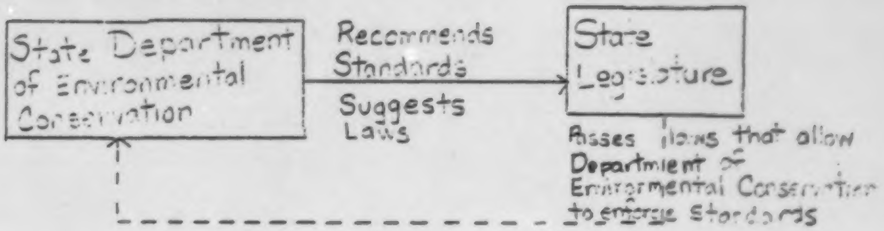
4. Explain how these standards are determined. Discuss the use of plant and animal studies in determining harmful levels of pollutants. Discuss the work of field biologists and ecologists in determining what is happening to the environment.

5. Once it is found that a certain level of pollution is dangerous, what can be done to keep pollution or destruction of the environment below that level? Discuss the method by which environmental legislation is enacted. Use the following flow charts:

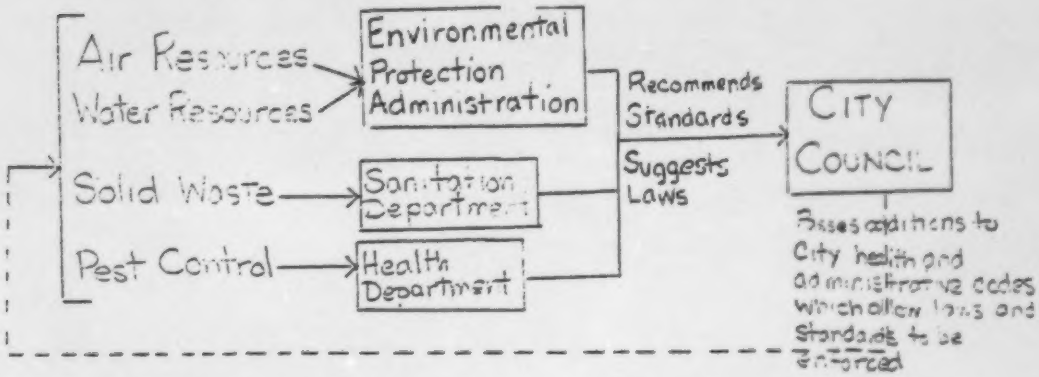
   a) Federal



b) State- New York State


State Department of Environmental Conservation
Recommends Standards
Suggests Laws
State Legislature
Passes laws that allow Department of Environmental Conservation to enforce Standards

c) Local-New York City


Air Resources
Water Resources
Solid Waste
Pest Control
Environmental Protection Administration
Sanitation Department
Health Department
Recommends Standards
Suggests Laws
CITY COUNCIL
Passes additions to City health and administrative codes which allow laws and Standards to be enforced

6. Why is it necessary to have laws passed on the national, state, and local levels? Discuss the local, state, and national responsibilities for maintaining the environment

7. What branch of government (Federal, state, or local) has the responsibility for controlling each of the following environmental problems?
   a) Land developers want to fill in all the wetlands and swamps along the shores of Long Island, Queens, the Bronx, and Brooklyn.
   b) Oil tankers sailing between Texas and New York City are leaking oil into coastal waters.
   c) A flower called the "Lady slipper" is almost extinct in New York State because of careless picking by campers.
   d) A furniture factory on 9th Avenue in Manhattan is releasing saw dust and spray paint into the air near a school building.

Lesson 119 The Role of the Individual in the Environment

Aim: "What can I do?"

Materials

pamphlets, posters, leaflets, etc. from various environmental action groups

Objectives

To understand the role of the individual in formulating sound environmental policy
To familiarize students with environmental action groups on local, national, and international levels
To appreciate the accomplishments of various environmental groups

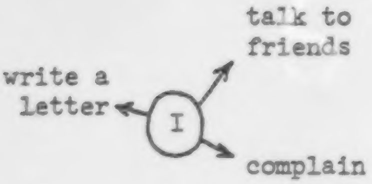
Strategies

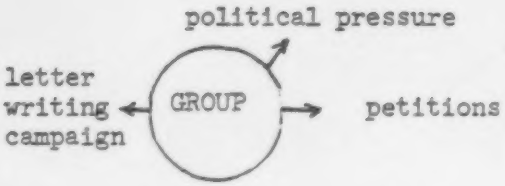
1. Carry out the following role plays with some students:
"You are residents of Howard Beach, Queens. You have paid a good deal of money for your homes which are in a quiet, residential area. The Port Authority of New York and New Jersey has just announced plans to allow the SST at Kennedy Airport. The landing pattern of the planes takes them right over your house. What can you do about it?

2. List the various solutions on the board. Point out the negative aspects of such solutions as selling a home or running away from the problem.

3. Which of these solutions can best be handled by a group? Examples would be petitions, letter writing campaigns, peaceful demonstrations. Discuss why group efforts are generally more effective than individual efforts.

   Place the following on the board.





   Elicit that group efforts are more directed and more effective.

4. Challenge students to "organize" an environmental action group. How would they go about it? Discuss some of the goals the group should have. Use the following examples of groups with specific goals.
   a) I Love a Clean N.Y. Committee- works with the Sanitation Department on anti-littering campaigns and block clean-ups.

b) Citizens Committee for a Better New York was organized to help individuals and community groups in putting together projects that would help the city during fiscal crisis.

c) Save Sunfish Pond Committee was organized by residents of New Jersey and Pennsylvania to prevent a dam project on the Delaware River that would have destroyed a beautiful lake.

d) The Sierra Club, an international organization. Originally its goals were in the area of wildlife conservation. Recently the group has spread out into areas of population control, the SST, and the over-use of pesticides.

5. Have students think of some environmental problems in their own neighborhoods. Here are some problems and existing organizations they can contact.
   a) Dirty lots- can be turned into gardens and parks - contact the Council on the Environment for New York City
      51 Chamber Street
      New York, N.Y. 10007
   b) Littered Streets - contact
      Civilian Sanitation Patrol
      125 Worth Street
      New York, N.Y. 10007
   c) Dirty or broken-up playground or park
      Citizens Committee for a Better New York
      Adopt-a-Park Program
      345 Park Avenue
      New York, N.Y.
   d) Other volunteer programs
      Mayor's Volunteer Corps
      51 Chambers Street
      New York, N.Y.

6. Explain the formation of "Ad Hoc" committees or groups of people that join together to solve a simple common problem. Suggest uses of ad hoc committees to solve local environmental problems.

Lesson 120 Environmental Careers

Aim: Can you make a career of environmental work?

Objectives

To identify occupations that involve environmental work
To understand the growing need for trained environmental technicians

Strategies

1. The field of environmental careers is an expanding one that many students can get involved in. These job requirements range from little skill to very advanced study. The need for educators, technicians, and researchers is expected to reach over 1.5 million positions. Jobs are opening up in the city, state, and federal levels as well as in private industry.

2. Why are there so many jobs becoming available? Discuss the implications of Federal Environmental Laws.

3. What are some of the types of jobs available in the environmental field?
    a) Environmental equipment operation:
        incinerator plant attendant
        wildlife attendant
        waste-water treatment plant operator
        sanitary landfill equipment operator
        solid waste systems manager
    b) Environmental technologists:
        inspectors
        nuclear technicians
        mechanical testers
    c) Environmental technology and education:
        educators, environmental engineers, environmental health services, environmental planners, natural resource managers, sanitation toxicologists, urban planners, soil conservationists
    d) Environmental science and research marine or aquatic biologist, entomologist, agronomist, epidemiologist, oceanographer, environmental law specialist

4. Students can obtain copies of Career Choices - produced by the E.P.A., January 1977.

5. If possible, arrange for guest speakers to discuss the job in which they are involved.

ADDITIONAL TEACHER NOTES

SCIENCE VOCABULARY WORDS

The following is a listing of words and/or terms used throughout this program. The words have been underlined to emphasize their importance. Teachers are urged to familiarize students with the meaning of these words; and to encourage the incorporation of these into the student's science vocabulary section.

1. abortion
2. adaptation
3. "Ad Hoc" committees
4. air pollution
5. alpha particle
6. amplitude
7. anaerobic organism
8. anthracite
9. aquifer
10. arachnids
11. atom
12. barrier island
13. beta particle
14. binary fission
15. biocide
16. biodegradable
17. biome
18. birth control
19. bituminous
20. bond
21. breeder reactor
22. broad-spectrum biocide
23. budding
24. bulkhead
25. carbon block
26. carbon dioxide
27. carbon monoxide
28. carcinogen
29. carrying capacity
30. ceiling population
31. cell
32. chain reaction
33. chlorinated hydrocarbon
34. chromosome
35. climax community
36. coal gasification
37. combustion
38. commensalism
39. community
40. competition
41. condensation
42. coniferous forest biome
43. contact poisons
44. control rods
45. cooling system
46. Coriolis effect
47. covalent bond
48. crater
49. critical mass
50. data
51. deciduous forest
52. demographer
53. delta
54. desalination
55. desert
56. dichotomous key
57. dissolved oxygen
58. doubling time
59. ecological
60. effluent
61. egg
62. electric generator
63. electrons
64. electrostatic precipitator
65. element
66. endangered species
67. energy
68. English sparrow
69. environment
70. equivalents
71. euthanasia
72. eutrophication
73. exotic
74. exponential
75. external fertilization
76. extinct
77. fallout
78. family planning
79. fertilization
80. fissure
81. fuel cell
82. fluoride
83. fluorosis
84. fulcrum
85. food chain
86. food web
87. force
88. friction
89. fusion reaction
90. gamete

91. gamma ray
92. geothermal energy
93. gestation period
94. grafting
95. grassland
96. habitat
97. half life
98. home range
99. host
100. human interference
101. hydrocarbon
102. hydroelectricity
103. hypothesis
104. imported species
105. inference
106. insect
107. insect sterility
108. integrated control program
109. internal fertilization
110. intertidal zone
111. ionic bond
112. ionosphere
113. isotope
114. juvenile hormone
115. kilowatt
116. kilowatt hour
117. kinetic energy
118. landfill area
119. lake
120. latitude
121. lava
122. lead
123. lignite
124. limiting factor
125. load
126. location
127. magma
128. megalopolis
129. mesosphere
130. mitosis
131. molecule
132. moraine
133. mutualism
134. natural enemy
135. natural predator
136. neutron
137. niche
138. nitric oxide
139. nitrogen
140. nitrogen dioxide
141. nonselectivity
142. nuclear energy
143. nuclear fusion reaction
144. nutrient agar
145. observation
146. oil dumping
147. orbiting solar collector
148. organ of Corti
149. ovary
150. overpopulation
151. oviduct
152. ozone
153. ozone layer
154. parasite
155. parasitism
156. particulate pollution
157. permafrost
158. pesticide
159. pheromone
160. photosynthesis
161. picture key
162. pistil
163. pollen
164. pollination
165. pollutant
166. pollution
167. pond
168. population
169. population density
170. precipitation
171. predator
172. pregnancy
173. prey
174. proton
175. Pyramid of Numbers
176. radiation
177. radioactivity
178. range
179. regeneration
180. reproduction
181. reservoir
182. resistance
183. resistant crop varieties
184. rhizomes
185. rhythm method
186. rodent
187. runner
188. sanitary landfill
189. scavenger
190. secondary succession
191. seed
192. sewage
193. sex attractants
194. shielding
195. sociologist
196. soil
197. solar energy
198. solubility

199. soot
200. sound
201. sperm
202. spore formation
203. stamen
204. stomach poison
205. stratosphere
206. stem cutting
207. sterilization
208. succession
209. sulfur dioxide
210. taiga
211. temperate
212. temperature
213. terminal moraine
214. territory
215. The Greenhouse Effect
216. thermal
217. thermonuclear reaction
218. tidal power
219. tissue
220. troposphere
221. tuber
222. turbine
223. tundra
224. uranium pile
225. urban sprawl
226. uterus
227. vagina
228. valence number
229. vaporization
230. vegetative propagation
231. water table
232. watershed
233. watt
234. weather
235. wind
236. word key
237. zero population growth

Appendix A
FIELD TRIPS: SUGGESTED FIELD SITES

The key to trip-taking is thorough preparation. Get to know your destination. Explore what it has to offer your group and how best to get the most from it. Avail yourself of any and all introductory workshops. Familiarize yourself with rules, regulations, and constraints. There is no better way than to make a pre-trip excursion to the resource facility and experience it first-hand.

The following is a listing of suggested sites which may be used for planning appropriate field experiences for your students. Field activities can be rewarding and enjoyable experiences for both student and teacher. To ensure the success of a field activity, consult reference books and resource sites in our city.

Alley Pond Environmental Center
228-06 Northern Blvd.
Little Neck, N.Y. 11363

American Museum of Natural History
Central Part West at 79th St.
New York, N.Y. 10024
General information: 873-1300
School groups: 873-7320

Brooklyn Botanic Garden
1000 Washington Avenue
Brooklyn, N.Y. 11225
622-4433

Brooklyn Children's Museum
145 Brooklyn Avenue
Brooklyn, N.Y. 11213
735-4400

Bronx Zoo
Bronx, N.Y. 10460
220-5131

Central Park Zoo
64th Street off 5th Avenue
288-6942

Department of Sanitation
Public Information Office
Room 731
125 Worth Street
New York, N.Y. 10013
577-5527

Hall of Science
Flushing Meadow Park
P.O. Box 1032
Flushing, N.Y. 11352

High Rock Park Conservation Center
200 Nevada Avenue
Staten Island, N.Y. 10306
987-6276

Museum of the American Indian
Broadway at 155th Street
New York, N.Y. 10032

Magnolia Tree Earth Center
1512 Fulton Street
Brooklyn, N.Y. 11216

National Maritime Historical Society
2 Fulton Street
Brooklyn, N.Y. 11201

New York Aquarium
Boardwalk and West 8th Street
Brooklyn, N.Y. 11224
General information: 266:8624

New York Botanical Garden
Bronx Park New York
Bronx, N.Y. 10458
220-8736

The New York Experience
McGraw-Hill Building
1221 Avenue of the Americas
New York, N.Y. 10020

New York Historical Society
170 Central Park West
New York, N.Y. 10024
873-3400

Queens Botanical Garden
43-50 Main Street
Flushing, N.Y. 11355
TU-6-3800

Queens Zoo
111th St. and 54th Ave.
Flushing Meadow
Queens, N.Y. 11368
699-7239

Richmondtown Restorations
302 Center Street
Staten Island, N.Y. 10306

South Street Seaport Museum
16 Fulton Street
New York, N.Y. 10038
766-9062

Staten Island Botanical Gardens, Inc.
914 Richmond Terrace
Staten Island, N.Y. 10341
351-4612

Staten Island Children's Museum
15 Beach Street
Staten Island, N.Y. 10304

Staten Island Museum
75 Stuyvesant Place
Staten Island, N.Y. 10301

Staten Island Zoo
614 Broadway
Staten Island, N.Y. 10310

U.S. Department of the Interior
National Park Service
Gateway National Recreation Area
Park Headquarters
Floyd Bennett Field
Brooklyn, N.Y. 11234
252-8104

Appendix B

PROJECTS RELATING TO THE ENVIRONMENT

Projects dealing with the environment can be assigned on a weekly, monthly, or quarterly basis. These projects should be designed to encourage and allow the student to utilize the learnings and skills developed during the course of the program. Several areas for project consideration are suggested.

I. Neighborhood Surveys

These projects require students to survey their neighborhood for environmental problems. An environmental problem, as defined by some environmentalists, is anything in the surroundings that takes away from the beauty or functioning of the community. Groups of students can work in committees to report these problems to the appropriate city agency for correction. It is important to stress accurate reportings of problems, including house numbers or compass directions and streets as in the case of potholes. By studying and tabulating corrected problems, students can better understand how local government functions. Follow-up on the work performed by action groups can help students understand the impact of action groups on various agencies.

II. The Environment in the News

Newspaper and magazine articles are important in helping to keep students aware of and up to date on environmental issues. With this in mind, students should be encouraged to collect newspaper and/or magazine articles. Students may follow developments in a specific area, or collect articles on a variety of issues. Articles submitted for study may be accompanied by a short written explanation describing how the problem relates to environmental science.

III. Environmental Issues Report

So that students can broaden their perception of the scope of an environmental issue, students can select an article to read from a magazine that reports on such issues on a regular basis. It may be advisable for the teacher to check each article before the students begin their report.

Appendix C

SELECTED TEACHER REFERENCES

American Chemical Society. Cleaning Our Environment. The Chemical Basis For Action. Washington, D.C.: American Chemical Society, 1969.

Andrews, William A. (editor). A Guide to the Study of Freshwater Ecology. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

Andrews, William A. (editor). A Guide to the Study of Soil Ecology. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1973.

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Clapham, Jr. W.B. Natural Ecosystems. The MacMillan Co., 1973.

Coale, Ansley J. "The History of the Human Population." Scientific American, September 1974, 231:40-51.

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Cox, George W. (editor). Readings in Conservation Ecology. New York: Appleton Century-Crofts, 1969.

Ehrlich, Paul. Human Ecology: Problems and Solutions. San Francisco, California: W.H. Freeman and Co., 1973.

Farb, Peter. The Insects. New York: Time-Life Books, 1962.

Grozier, Mary and Roberts, Richard. New York's City Streets, New York: The Council on the Environment of New York City, 1973.

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Heller, Robert L., et al. Earth Science. New York: McGraw-Hill Book Company, 1973.

Ingmanson, Dale, and Wallace, William J. Oceanology: An Introduction. California: Wadsworth Publishing Co. Inc., 1973.

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Kjellstrom, Bjorn. Be Expert With Map And Compass. New York: Charles Scribner's Sons. 1976.

Kormondy, Edward J. Concepts of Ecology. 2nd edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.

Landau, Norman and Rheingold, Paul. The Environmental Law Handbook. New York: Ballantine Books, 1971.

McKevan, D.K. Soil Zoology. Washington, D.C.: Butterworth, 1955.

Navarra, John Gabriel and Strahler, Arthur N. Our Environment in Space. New York: Harper and Row, 1973.

O'Brien, Robert. Machines. New York: Time-Life Books, 1964.

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Ursin, Michael. Life In And Around The Salt Marsh. New York: Thomas Crowell Co., 1972.

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Went, Frits W. The Plants. New York: Time-Life Books, 1963.

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Wolozin, Harold. Energy and the Environment. Morristown, New Jersey: General Learning Press, 1974.

Appendix D

SELECTED STUDENT REFERENCES

Abbott, R. Tucker. A Guide to Field Identification: Seashells of North America. New York: Golden Press, 1968.

Abraham, Norn, et al. Interaction of Man and the Biosphere. New York: Rand McNally and Company, 1975.

Andrews, William A. (editor). A Guide to Urban Studies. Scarborough, Ontario: Prentice-Hall of Canada, 1976.

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Bishop, Margaret S.; Lewis, Phyllis G.; and Sutherland, Berry. The Environment. Columbus, Ohio: Charles E. Merrill Publishing Co., 1976.

Borror, Donald J., and White, Richard E. A Field Guide to the Insects of America. Boston: Houghton Mifflin Co., 1970.

Brockman, Frank C. Trees of North America. New York: Golden Press, 1968.

Buchsbaum, Ralph. Basic Ecology. California: The Boxwood Press, 1957.

Cunningham, John D. Biology: You and Your Environment. Lexington, Mass.: D.C. Heath and Company, 1976.

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Jahn, Theodore L. and Jahn, J. Francis. How to Know the Protozoa. Dubuque, Iowa: Wm. C Brown Co., 1949.

Jaques, Harry E. How to Know the Insects. Dubuque, Iowa: Wm. C. Brown Company, 1947.

Knobel, Edward. Identify Trees and Shrubs by Their Leaves. New York: Dover Publications, Inc., 1972.

Lehr, Burnett, and Zim, Herbert. Weather. New York: Golden Press, 1957.

Levi, Herbert Wand, and Levi, Lorna R. Spiders and Their Kin. New York: Golden Press, 1969.

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Perlmutter, Alfred. Guide to Marine Fishes. New York: N.Y.U. Press, 1961.

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Rash, T. Keogh. The Pollution Problem: Protecting Our Environment. New York: Globe Book Co., 1975.

Stokes, Donald. A Guide to Nature in Winter. Boston, Mass.: Little Brown and Co., 1976.

Voss, Gilbert. Oceanography. New York: Golden Press, 1972.

Appendix E
RESOURCE ORGANIZATIONS

Action
806 Connecticut Ave. NW
Washington, D.C. 20525

Air Pollution Control Association
440 Fifth Avenue
Pittsburgh, Pa. 15213

Alliance for Environmental Education Inc.
Executive Director
1225 Country Club Road
Warsaw, In. 46580

The Aluminum Association
818 Connecticut Avenue, NW
Washington, D.C. 20006

American Association for the Advancement of Science
1515 Massachusetts Ave, NW
Washington, D.C. 20005

American Conservation Association
30 Rockefeller Plaza
New York, N.Y. 10020

American Forest Institute
1619 Massachusetts Avenue
Washington, D.C. 20036

American Gas Association
Educational Services
1515 Wilson Boulevard
Arlington, Virginia 22209

American Geographical Society
Broadway at 156th Street
New York, N.Y. 10032

American Littoral Society
Sandy Hook
Highlands, N.J. 07732

American Lung Association
1740 Broadway
New York, N.Y. 10019

American Museum of Energy
P.O. Box 117
Oak Ridge, Tennessee 37830

American Society for Ecological Education, Inc.
c/o Curry College
Milton, Ma. 02186

American Water Resources Association
P.O. Box 434
Urbana, Il. 61801

Brooklyn Botanic Garden
1000 Washington Avenue
Brooklyn, N.Y. 11225

Brooklyn Union Gas
195 Montague Street
Brooklyn, N.Y. 11201

Bureau of Land Management
Building 53
Denver Federal Center
Denver, Colorado 80225

City of New York
Environmental Protection Administration
2345 Municipal Building
New York, N.Y. 10007

Comm. for Environmental Information
560 Trinity Avenue
St. Louis, Mo. 63130

Conservation and Environmental Studies Center, Inc.
Box 2230, RD7
Browns Mills, N.J. 08015

Council on the Environment of N.Y.C.
51 Chambers Street, Rm. 228
New York, N.Y. 10007

Council on Population and Environment, Inc.
100 E. Ohio St.
Chicago, Ill. 60611

Dept. of Environmental Conservation
Bureau of Community Assistance
Room 412
50 Wolf Road
Albany, N.Y. 12233

Ecological Society of America
Oak Ridge National Laboratory
Radiation Ecology Division
Oak Ridge, Ten. 37831.

Energy Research and Development Administration
Office of Public Affairs
Washington, D.C. 20545

Environmental Action Coalition
156 5th Avenue
New York, N.Y.

Environmental Protection Agency of the City of New York
Department of Air Resources
120 Wall Street
New York, N.Y. 10005

Federal Water Pollution Control Administration
Federal Building
Boston, Mass. 02203

Institute of Environmental Sciences
34 South Main Street
Mt. Prospect, Il. 60057

National Association of Soil and Water Conservation Districts
1025 Vermont Avenue, N.W.
Washington, D.C. 20005

National Energy Foundation
521 Fifth Avenue Room 1006
New York, N.Y. 10017

National Science Foundation
1800 G St. N.W.
Washington, D.C. 20550

The Population Reference Bureau Inc.
1755 Massachusetts Ave. N.W.
Washington, D.C. 20036

Student Conservation Association, Inc.
Route 1, Box 573-A
Olympic View Dr.
Vashon, WA 98070

Thorne Ecological Institute
2305 Canyon Blvd. Boulder, Co. 80302

Smithsonian Institute
1000 Fefferson Dr., S.W.
Washington, D.C. 20560

U.S. Department of Energy
Office of Information
Washington, D.C. 20545

Water Pollution Control Federation
3900 Wisconsin Avenue
Washington, D.C. 20016

Wildlife Management Institute
709 Wire Building
Washington, D.C. 20025

Zero Population Growth
1346 Connecticut Ave. N.W.
Washington, D.C. 20036

Appendix F

CAREER INFORMATION

Opportunities in Environment Careers
Odom Fanning
$3.95 paper
Vocational Guidance Manuals - 1975
620 South 5th Street
Louisville, Kentucky 40202

U.S. Dept. of Agriculture
Forest Service
Move Ahead- Research Careers in the Forest Service
Misc. Publication No. 1109
U.S. Dept. of Agriculture
Forest Service
Washington, D.C. 20250

U.S. Office of Education
Career Education in the Environment
Washington, D.C. U.S. Gov't Printing Office

U.S. Government
Careers in Forestry
U.S. Gov't Printing Office
Washington, D.C. 20401- 15¢

West Virginia University
Careers in Forestry for Women
West Virginia University
Morgantown, W. Va. 26506

U.S. Dept. of Agriculture
Forest Service
Career Packet
Washington, D.C. 20250

Career Education in the Environment
Olympus Research Corporation
818 18th St. N.W.
Washington, D.C. 20006

Civil Engineer and Mechanical Engineer
Two profiles-
U.S. Department of Agriculture, Forest Service
Washington, D C. 20250

"Careers in fish and game management"
(reprint) The Conservationist
June-July, 1964
New York Department of Conservation, Albany, N.Y. 12226

Careers in Wildlife Conservation
Conservation Department
Olin Industries, East
Alton, Illinois 62024

Careers for Women in Conservation
Leaflet No. 50, U.S. Department of Labor
Women's Bureau
Washington, D.C. 20240- 10¢

Careers in Biology
American Institute of Biological Sciences
3900 Wisconsin Ave. N.W.
Washington, D.C. 20016

Careers in Marine Sciences
FAO Fish
Tech. Paper 90 (1969)
Food and Agriculture Organization of the United Nations

Careers in the National Park Service
U.S. Department of the Interior
National Service
Washington, D.C. 20240

Careers in Conservation
Soil Conservation Society of America
7515 N.E. Ankeny Road
Ankeny, Iowa 50021

Careers in Botany
Botanical Society of America, Dept. of Botany
University of Texas
Austin, Texas 78710

Women in the Forest Service
Division of Personnel Management
Forest Service, U.S. Dept. of Agriculture
Washington, D.C. 20250

A Wildlife Conservation Career for You
S-176, The Wildlife Society
3900 Wisconsin Ave. N.W.
Washington, D.C. 20016

Your Career and Clean Water for America
U.S. Federal Water Pollution Control Administration
Washington, D.C. 20000

Appendix G

SOURCES OF AUDIO-VISUAL MATERIALS

Audio-visual materials are an integral part of the learning process. In this program, they are intended to be used to enrich and extend the lesson rather than replace it. To help determine whether specific items are appropriate for interest level and class ability, all materials should be carefully selected and viewed in advance.

The following is a listing of audio-visual suppliers which prepare media materials in the environmental sciences. Catalogues are available upon request.

ACI
Films (516) 4660297
2 60-08 Kensington Pl.
Great Neck, N.Y. 11020

ASSOCIATION FILMS, INC.
866 Third Avenue
New York, N.Y. 10022

BERGWALL PRODUCTIONS, INC.
839 Steward Avenue
Garden City, N.Y. 11530

BFA Ealing Educational Media
2211 Michigan Avenue
Santa Monica, Calif. 90404

CARMAN EDUCATIONAL ASSOCIATES
Box 267
Youngstown, N.Y. 14174

CENTRON FILMS
1621 W. 9th St.
Box 687
Lawrence, Kansas 66044

CENTER FOR HUMANITIES
2 Holland Avenue
White Plains, N.Y. 10603

DEPT. OF ENERGY
P.O. Box 62
Oak Ridge, Tenn. 37830

DOUBLEDAY MULTIMEDIA
Att: Sales Promotion Dept.
P.O. Box 11607
Santa Anna, Calif. 92705

EDUCATIONAL AUDIO-VISUAL INC.
Customer Service Dept.
Pleasantville, N.Y. 10570

EDUCATIONAL DIMENSIONS
c/o Jerry Waters Assoc.
Box 211
Coram, N.Y. 11727

ENCYCLOPAEDIA BRITANNICA EDUCATIONAL CORPORATION
425 N. Michigan Avenue
Chicago, Illinois 60611

EYE GATE MEDIA
146-01 Archer Ave.
Jamaica, N.Y. 11434

HANDEL FILM CORPORATION
8730 Sunset Boulevard
West Hollywood, California 90069

HARPER & ROW
Harper and Row Media
10 E. 53 Street
New York, N.Y. 10022

HUBBARD
P.O. Box 104
Northbrook, Ill. 60062

INQUIRY AUDIO-VISUALS
1754 West Farragut Ave.
Chicago, Illinois 60640

McGRAW-HILL FILMS
1221 Ave. of the Americas
New York, N.Y. 10020

MODERN TALKING PICTURE SERVICE, INC.
2323 New Hyde Park Road
New Hyde Park, N.Y. 10040

MOODY INSTITUTE OF SCIENCE
12000 E. Washington Blvd.
Whittier, California 90606

NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION
Washington, D.C. 20546

NATIONAL FILM BOARD OF CANADA
16mm Films available for purchase and
rental in the United States

NATIONAL GEOGRAPHIC EDUCATIONAL
SERVICES
17th and M Streets, N.W.
Washington, D.C. 20036

NEW YORK STATE DEPT. OF ENVIRONMENTAL
CONSERVATION
Albany, N.Y. 12233

NYSTROM
3333 Elston Ave.
Chicago, Ill. 60618

OXFORD FILMS, INC.
A subsidiary of Paramount Pictures
Corp.
1136 N. Los Palmas Ave.
Los Angeles, Calif. 90038

PICTURA FILMS DISTRIBUTION CORPORATION
43 West 16 Street
New York, N.Y. 10011

PRENTICE HALL MEDIA
150 White Plains Road
Tarrytown, N.Y. 10591

SCHOLASTIC
904 Sylvan Ave.
Englewood Cliffs, N.J. 07632

SCIENCE AND MANKIND INC.
2 Holland Ave.
White Plains, N.Y. 10603

SCIENCE SOFTWARE SYSTEMS, INC.
11899 West Pico Blvd.
West L.A., Calif. 90064

SHELL FILM LIBRARY
1433 Sadlier Circle W. Drive
Indianapolis, Indiana 46239

SINGER-SOCIETY FOR VISUAL EDUC., INC.
1345 Diversey Pkway
Chicago, Ill. 60614

SUNBURST COLOR SOUND FILMSTRIPS
41 Washington Avenue Room 8282
Pleasantville, N.Y. 10570

TIME LIFE MULTIMEDIA
Distributing Center
100 Eisenhower Drive
Paramus, N.J. 07652

WARD'S NATURAL SCIENCE ESTABLISHMENT
INC.
Modern Learning Aids Division
P.O. Box 1712
Rochester, N.Y. 10460